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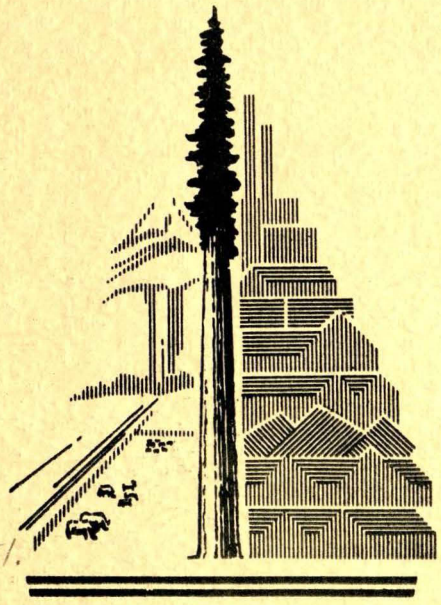

U. S. DEPARTMENT OF AGRICULTURE · FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
R. W. COWLIN, DIRECTOR
PORTLAND, OREGON
MARCH 1955

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ANNUAL REPORT OF THE PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION FOR THE CALENDAR YEAR 1954

INTRODUCTION

Measured in terms of population, payrolls, industrial volume, farm products, and homes, our economy in the Pacific Northwest (Oregon and Washington) is expanding and maturing at a rapid rate. Between 1940 and 1950, population increased 38 percent, per capita income 260 percent, value of manufactured products 360 percent, value of agricultural products 280 percent, and sale of electric energy 450 percent.

Despite remarkable development of metallurgical and other industries attracted by relatively cheap hydroelectric power, the timber industries, including the growing of forest crops and the harvesting and manufacture of all kinds of wood products, continue to be the mainstay of the region's economy. This fact sharply directs attention to the basic resource--the forest--which not only supports these industries but also serves many other useful purposes. Obviously, the progress we make in learning how to grow and utilize forest crops most effectively can increase or limit future growth and prosperity. Therefore, an imaginative, adequate, and well-directed program of research in the multiple aspects of natural resource management is necessary. Progress in research is necessary not only to us in the Pacific Northwest but also to the entire country because this region supplies a major part of the Nation's wood products. At the present time, this region produces about one-third of the Nation's lumber, one-sixth of the wood pulp, over nine-tenths of the softwood plywood, and large volumes of other wood products.

A few more figures will show the values at stake and the obvious need for forest research in these two States. Currently the annual value of all forest products manufactured in Oregon and Washington combined is about 2 billion dollars. Nearly three-quarters of a billion dollars is paid annually in wages to about 175,000 workers in this area.

A balanced research program must not be restricted to ways of growing and harvesting trees and making wood products. It must tell us how to protect the forests against fire, insects, and disease. It must provide the tools for managing the forage and browse in forest areas upon which livestock and game animals feed and, most important, it must tell us how best to develop and manage our forested watersheds so that water for farms, homes, factories, and outdoor playgrounds can be improved in quality and quantity.

Our research program deals not only with the flora and fauna and the soil, water, and climate, but also with the economic and social factors.

Our job is to design, implement, and conduct a program which serves all these broad purposes of resource management and development.

Experience and judgment prove that the program must be constantly developing and expanding in step with our economy. We also have learned that this end cannot be accomplished through scholarly isolation. Other disciplines, other economies, and situations existing in all parts of the country and the world must be known and considered. Obviously then, our job is to help others and to seek help from others who hold the same broad objectives of improving our country's economic and social welfare. The Station's part in this effort is reported for 1954 in the following pages. Some of the study projects may seem remote from the total purpose. Again, history has shown how scientific discoveries which may seem unimportant or abstract at the time can expand into momentous developments or become of great practical value as we learn their true import. The constant possibility of turning fundamental research to practical use illustrates the need to increase our basic knowledge of the sciences. At the same time, the rapid advance of progressive forest and range management practices compels attention to immediate demands for answers from research. Thus we must balance our research program, keeping long-range and immediate needs in mind constantly.

A few highlights of the past year's program deserve special notice in this introduction. The Forest Survey completed its part of the nationwide Timber Resource Review and at the same time covered nearly 3½ million acres in its reinventory program. We still need to accelerate this work by at least one-third above the present rate if we are to keep abreast of the critical demands for up-to-date information on our region's forest resources. During 1954, plans were completed for initiation of a forest economics program at the Station and early in 1955 a forest economist will join the staff and work will get under way. In forest utilization we are continuing to progress towards finding economical use of the woods and mill residues.

Outstanding in forest management research were the reactivation of the Willamette Research Center with headquarters at Corvallis, Oreg., and the beginning of a forest genetics research program. Both of these steps were accomplished through the cooperative assistance of the School of Forestry, Oregon State College. Our watershed management research program grew slightly with establishment of debris catchment basins at the Starkey Experimental Forest and Range. This is only a small start on a program which will fill a major gap in our research work.

Forest insect research moved ahead with major effort on biological studies and control of the spruce budworm, the studies and surveys of the Douglas-fir bark beetle, and appraisal of the problem of the silver fir beetle. Research in the biology of the latter insect is also expanding. A research program in survey techniques was started. This should result in making our surveys more effective and economical. Likewise, in forest disease research, work was concentrated on a relatively few pests--Douglas-fir and Port-Orford-cedar root rots, pine mistletoe, and pine needle blight. A small start was made on certain aspects of blister rust as it affects sugar pine management in southern Oregon. The integration of the Divisions of Forest Insect and Forest Disease Research was accomplished smoothly during the year. As a result of this move the entire research program of the Station has been strengthened.

Completion of the physical facilities at Starkey Experimental Forest and Range is in sight and the study phase of the grazing management project is now under way.

These and the many other accomplishments of the Station during 1954 were helped greatly by the development and strengthening of our cooperative relationships. Early in 1954, the Station's advisory committee was organized, and held its first meeting in February and the second in November. Advice of this group and the research center advisory committees was of considerable assistance in review of the Station's program and plans for its conduct. Our progress was also assisted by the fine cooperation of many public agencies, institutions, industrial concerns and associations, and private individuals.

In June, we moved into new quarters in Portland, located at 729 N. E. Oregon Street. This move brought us under the same roof with the Regional Office of the Forest Service, which greatly assists the Station's work and enables both of us to serve the public better and more conveniently. It also allowed us to bring the Division of Forest Disease Research in the same quarters with the other Station divisions and gave us needed laboratory space.

We recommend for your information and consideration detail of the Station's 1954 progress and plans for 1955 which follow. We also solicit your questions for information not covered in the report and any suggestions you may have regarding the Station's work.

FOREST ECONOMICS

A New Start in Forest Economics Research

In the past, the division's work in the field of forest economics has dealt very largely with the Forest Survey and allied projects or with special surveys made in connection with the Nation's defense program or as part of periodic national appraisals of the timber resource situation. In July, however, funds were allotted the Station to make a modest start on research studies of economic problems having to do with the management and utilization of the multi-resources of the region's forest lands. Assignment to carry on these studies has been made, and it is planned to begin actual work early in 1955. This initial annual allotment for economic studies is encouraging. It is hoped that it will lead to major expansion of research in this field in the Pacific Northwest.

Timber Resource Review Tasks Completed

The division had major responsibility for preparation of the Pacific Northwest Region's reports on Tasks V, VI, and VII and cooperated on certain phases of Task VIII. The report for Task V was completed early in the year. It dealt with output by products and the amount of timber removed from growing stock; logging and plant residue volume and use were

a part of this utilization picture. Work on the Timber Resource Inventory, Task VI, was completed in April. This Task involved estimates and analyses of forest land acreages, timber volume, timber quality, annual timber growth, and annual timber mortality. Work on the several phases of Task VII was completed in September. The objective was to establish trends of timber growth and present empirical estimates of future growth and growing stock based on recent forestry trends and various assumptions as to timber products output.

At the time of collection of data for Task VIII, Status of Timber Management, Regional Office field men, local forest officers, and cooperators obtained data on farm-owned forests. These sample data were used by the division to develop a breakdown of the privately owned commercial forest land acreage and timber volume in the region into two subclasses of ownership: "farm" and "industrial and other."

Forest Survey Reinventory Continues

The field work of Forest Survey reinventory was completed in seven counties during the past year; included were Columbia, Hood River, Morrow, and Wasco Counties in Oregon, and Klickitat, Thurston, and Yakima Counties in Washington. Total area of forest land covered was approximately 3,418,000 acres, two-fifths of which was in Oregon and three-fifths in Washington.

In the field work in the Mt. Hood National Forest in Hood River and Wasco Counties, and in the Snoqualmie National Forest in Yakima County, the forest supervisors cooperated by furnishing manpower with which to supplement the regular sample plot measurements. The additional plots resulting from this cooperation assured Forest Survey of timber-volume, growth, and mortality data of greater sampling accuracy, at no additional cost, than would ordinarily be obtained under the regular Forest Survey intensity of sampling. At the same time, the national forest working circle field data were collected at a reduced cost and were fully coordinated with Forest Survey information.

Detailed forest type maps were completed during the year for Deschutes, Harney, Jefferson, and Wheeler Counties, Oreg., and Kittitas County, Wash. Prints of these maps, on a scale of either 1 or 2 inches to the mile, are available to the public at cost of reproduction. Demand for the county type maps continues to be large. Considerable progress has been made in the preparation of base maps of the counties reinventoried during 1954 and in the projection of forest-type data, as delineated on aerial photos in the 1954 field season, to these base maps.

Computation of forest-type areas and timber volumes by ownership class and of rates of net annual forest growth and annual mortality was completed for Deschutes, Harney, Jefferson, Wheeler, and Kittitas Counties. Similar computing work has progressed well for the counties covered in the field during the past season.

County statistical reports presenting results of the reinventory were published for Crook, Clatsop, Deschutes, Harney, and Jefferson Counties, Oreg., and Kittitas County, Wash. Preparation of the report for Wheeler County, Oreg., was nearly completed. With the exception of Clatsop County, all of the counties listed are in the ponderosa pine subregion of eastern Oregon and eastern Washington.

A Few Significant Forest Survey Findings

In addition to presenting the usual forest area, volume, and ownership statistics, and related information, county reports in the past few years have given indications of important differences in the evaluation of the forest resource. Some of these changes are evident when old statistics are examined in the light of recent reinventories. One of the most striking observations is the reduction in nonstocked areas over the past 15 to 20 years. In 1938, for instance, Columbia County, Oreg., had 40 percent of its total forest area in recent cutover, nonstocked cutover, or deforested burn conditions. Recognizing some changes in classification, the 1954 field reinventory work showed an insignificant acreage in the nonstocked condition. Columbia County also shows a marked improvement in degree of stocking in the younger age classes. Good and well stocked seedling, sapling, and poletimber stands are much more common now than formerly. Similar situations have been found in other counties although the differences are not so striking.

Most of the recent reports show a rather large sawtimber volume in the primary species, Douglas-fir or ponderosa pine, in spite of active logging operations during the past decade and a half. Although quality may have been reduced somewhat, estimated volumes remain large because of changing specifications that reflect improved utilization practices, revised appraisals of merchantability and accessibility, as well as normal forest increment.

Twenty years ago the forest industries paid limited attention to many of the associated species which, by and large, had little market demand and at that time were generally considered to be of limited economic importance. Consequently, volume estimates were very conservative. Under present economic conditions and improved outlets for timber of all kinds greater stress is placed on these so-called minor species. Recent inventories generally show large increases over the volumes reported in the 1930's. Lodgepole is one case in point. Most of the stands of this species were considered as nonmerchantable. Presently, it is considered well-suited for pulp, is cut for poles, and sometimes sawn into lumber. A recent reinventory of Deschutes County, Oreg., shows the estimated sawtimber volume of lodgepole pine to be 771 million board feet, whereas in a 1934 inventory the volume was estimated at 114 million board feet. Part of this increase was due to net growth but the major portion was due to a difference in classification of merchantability.

Assistance Given on Industrial and Resource Analysis Problems

During the year there was an unusually large number of requests for up-to-date, and usually detailed, statistics on forest-land acreage,

timber volume and growth, and similar data for the forested areas in Oregon and Washington. These requests came from forest-industry companies, consulting firms, industrial associations, local community groups, and public and semi-public planning and research committees. This widespread interest in specific information on the forests of the region points to what is probably the number-one problem of most of the forest industries--a stable, long-term supply of raw material. Statistics of this type were prepared in answer to several separate requests from the Stanford Research Institute. A large volume of material was compiled for use of the Business Executives Research Committee under the sponsorship of the Ford Foundation. Chambers of commerce, newspaper editors, tax boards, and consulting foresters frequently ask for data on a great variety of timberland characteristics and potentialities.

Consolidation of Research Work on Bark-Beetle-Blowdown Problems

Research on the bark-beetle-blowdown problem in the Douglas-fir subregion, in which the division cooperated in 1952 and 1953, was consolidated this year in the Division of Forest Insect Research. Late in the year, one division employee transferred to Forest Insects Research to head up studies in insect-survey methods and techniques.

Plans for Economics Research in 1955

Forest economics research in the division will get under way at the beginning of the year with the assignment of one full-time technical man to the work. The initial effort will be limited to an intensive appraisal of the situation, the completion of a problem analysis, the selection of some specific projects, and the initiation of work on selected studies.

The exact work to be done has not been defined. Some potential general fields under consideration include studies designed to increase utilization of logging and mill residues, to show economic feasibility for new or additional industries to utilize low-grade wood material, to answer questions on economics of land use and criteria for determining suitability of land for potentially competitive uses, to evaluate costs and returns for various forest practices, and to point out use of labor and capital in further integration of timber products manufacture.

Plans for Forest Survey in 1955

During the early portion of the year it is planned to complete all phases of the office computation of inventory, growth, and mortality data collected in the field in the seven counties reinventoried in 1954. It is also planned to have the drafting of the detailed forest type maps of these counties completed by midsummer. It will be possible to obtain prints of these maps on a scale of either 1 or 2 inches to the mile.

County statistical reports, presenting results of the reinventories of Columbia, Hood River, Morrow, Wasco, and Wheeler Counties, Oreg.,

and Klickitat, Thurston, and Yakima Counties, Wash., are scheduled for preparation and publication during the year. The State report, "Forest Resources of Oregon," first published in 1942, will be brought up to date and published cooperatively with the School of Forestry, Oregon State College, and the Oregon State Board of Forestry. It is also planned to release a report on timber cut in the Pacific Northwest Region in 1952, which will present statistics on the production of timber products and the annual cut from live timber during the year.

Counties scheduled for field reinventory surveys during the year include Tillamook, Lincoln, and part of Lane in Oregon, and Snohomish County in Washington. Office computation of data and preparation of the forest type maps for these counties will be started in the latter part of the year, following the field season.

Research in forest survey methodology and techniques will continue so that survey standards may be improved or maintained at the lowest possible cost.

FOREST MANAGEMENT RESEARCH

Achievement in research can be measured in a number of ways, but relative success in developing new information is probably the most revealing. In forest management no spectacular discoveries can be claimed for 1954, but we believe the year's findings represent a healthy increment to the fund of information available on Northwest forests. We hope these findings will be helpful to forest owners in their efforts to do a better job of regenerating, growing and harvesting forest crops, and protecting them from fire.

Forest Genetics

The search for improved forest trees that will produce a maximum of usable wood in a minimum of time is not a new activity at the Station. The arboretum at Wind River was started in 1912 and was followed by a provenance study of Douglas-fir in 1913 and a study of ponderosa pine regional races in 1926. Efforts in this field were greatly strengthened during 1954, however, through the assignment of Roy Silen to genetics work full time. The project is headquartered at Corvallis, Oreg., where office, laboratory, greenhouse, and arboretum facilities are available through cooperation of the School of Forestry, Oregon State College.

Program for the Northwest. Information on regional needs in tree improvement research was assembled early in 1954 and a tentative program was distributed in August for review by interested foresters. The program calls for a three-way attack:

1. Production of more abundant and better quality tree seed for immediate use through selection and improvement of above-average natural stands.

2. Production of genetically superior seed for future forest planting through propagation in seed orchards of scions from carefully selected trees of outstanding characteristics (plus trees).

3. Species improvement, by orderly developing trees with genetically superior characteristics through selection, controlled pollination, hybridization, and progeny testing.

Following review and revision, this appraisal will be used in selecting high priority studies for the Station's program. It should also prove useful in strengthening cooperation and coordination among various individuals and agencies engaged in genetics research in the Northwest.

Improved seed collection areas. The Station is cooperating with the Regional Office of the Forest Service in selecting and developing two demonstration seed collection areas. One will be located in a west-side stand of Douglas-fir and the second in an east-side stand of ponderosa pine. As a first step, Isaac assembled existing knowledge on seed zones and the recognition and selection of plus trees and superior strains which will be summarized in a research note early in 1955. Also planned for 1955 is establishment of a registry where information on outstanding trees can be readily available for seed orchard development and species improvement research.

Douglas-fir heredity study. Remeasurement during 1954 brings up to date a 30-year record of relative growth of stock from 13 localities planted in 5 widely separated plantations. The records will be analyzed critically during 1955. Plantings are now approaching mid-rotation age and the analysis should provide valuable leads for new studies in forest genetics.

Forest Soils

Current studies concern effect of broadcast slash burning on soils of the Douglas-fir region. Attention is given not only to changes in chemical, physical, and biological properties but also to the effects of burning on germination and survival of Douglas-fir seedlings.

Work thus far shows that:

1. Effect of burning on soil varies widely depending on both type of soil and severity of burn.

2. Burning decreases acidity of all soil types but the change is less for highly acid coastal soils than for less acid soils of lower rainfall zones.

3. Within three years after burning, even severely burned soils return to the acid range, although they have not been restored to their original level of acidity.

4. Severe burning increases soil density and, in turn, reduces rates of water percolation and volume occupied by large pore spaces.

5. Change after burning from acid to alkaline condition does not hinder germination of Douglas-fir seed, but it may indirectly lower both germination and survival by favoring development of damping-off fungi.

Of special interest was the finding that intensity of burn varies greatly over a single cutting unit and that only a small portion of the surface is severely burned. A study of 10 units that had been clear-cut and broadcast burned showed that 47 percent of the surface area was not burned at all. Another 47 percent was lightly burned and only 3 percent was severely burned. The remaining 3 percent was non-seedbed (rock, etc.). These studies show that the changes wrought by severe burning apply to only a very limited portion of slash-burned areas

Planting

Long accepted as a standard method for restoring burns and old cutovers to forest cover, planting is now frequently employed as a primary means for restocking current clearcuttings in the Douglas-fir region. Even where an adequate source of seed has been reserved in the form of seed trees, seed blocks or leave settings, planting is often used to overcome the hazard of infrequent cone crops, shorten the regeneration period, and give conifer seedlings a head start on the brush. Though the Station's plantings studies cover many kinds of trees, 1954 findings are limited to two species.

Western hemlock has shown exceptional first-year survival on a bracken and brush-covered area in the Hemlock Experimental Forest, near Hoquiam, Wash. Of 2,500 seedlings planted during the winter of 1953, 90 percent were alive at the end of the first year. Stock (2-0) was donated by the British Columbia Forest Service. If the hemlock planting continues to thrive, it may prove to be a good species to plant on similar sites. It can be expected to outproduce Douglas-fir in this fog belt zone and is less susceptible than Douglas-fir to damage by deer and rabbits.

Port-Orford-cedar. Study of 26 plantations from northern California to Puget Sound demonstrates that survival of Port-Orford-cedar is generally satisfactory but growth is restricted by animal damage and by severe competition from other vegetation including volunteer trees. Age of plantings ranged from 8 to 26 years. Survival averaged 65 percent, based on the assumption that trees were actually planted at the planned spacing. This compares favorably with a 61 percent survival for Douglas-fir, which was included in 9 of the 26 plantings. Port-Orford-cedar survived better on moist than on well-drained soils and better on fine than coarse soils.

Annual height growth of planted Port-Orford-cedars averaged 0.8 feet. Height growth of Douglas-fir and volunteer western hemlock in the same plantations was almost twice as great. This difference in height growth is mostly attributed to heavier animal damage on the cedar. Altogether, 19 percent of the cedars were moderately or severely damaged by animals, compared to 8 percent of the Douglas-firs and 1 percent of the western hemlocks. Browsing by deer and elk accounted for 60 percent of the injuries, domestic livestock 15 percent, and rodents 25 percent.

Seeding

Development of promising rodent repellents and rodenticides continues to stimulate interest in direct seeding of Northwest trees. For several years, the Station has cooperated with the Fish and Wildlife Service, the national forests, and the State of Washington in pilot plant trials to determine the relative value of several candidate materials in seeding operations. This program was temporarily set back late in 1954 when tetramine, a promising rodenticide, became unavailable. However, the Denver Laboratory of the Fish and Wildlife Service has completed preliminary tests on two other likely materials which will be available for field testing in 1955.

Douglas-fir treated with tetramine (in acetone carrier) and sown in 1951 on the Capitol State Forest and in 1952 at Mayfield, both in Washington, showed good survival and vigor when final seedling counts were made in 1954. At Capitol State Forest, 45 percent of the mil-acre plots were stocked with seedlings. At Mayfield, the area sown to tetramine-treated seed was 62 percent stocked (mil-acre basis) in contrast to only 40 percent for a nearby area sown to untreated seed.

Sugar pine and ponderosa pine have been used in direct seeding trials at the Siskiyou-Cascade Center since 1950 in cooperation with the Umpqua and Rogue River National Forests. Examination last fall of a 1952 seeding of sugar pine on Zinc Creek showed that a well-stocked stand had resulted and that seedlings were thrifty and making good growth. Second-year mortality was light and stocking (4 mil-acre basis) now averages 72 percent. In this trial, seed was planted in prepared seed spots and bait was used to ward off rodents.

Seed, surface-coated with tetramine in dextrin, was used in fall (1953) seedings at Junction Springs on the Umpqua National Forest and at Union Creek on the Rogue River National Forest. In both trials, tetramine proved effective in protecting seed from rodents without lowering germination. At Junction Springs, six times as many ponderosa pine seedspots germinated where the tetramine-treated seed was used as where untreated seed was sown. For sugar pine, the difference was even greater. At the end of the first growing season, 66 percent of the sugar pine seedspots and 63 percent of the ponderosa pine seedspots supported one or more live seedlings.

New seedspotting trials installed during the fall of 1954 include a 20-acre sowing of ponderosa pine near Diamond Lake and a 100-acre sowing

of sugar pine on Zinc Creek. Baiting with 1080 and thallium sulfate is being used for protection against rodents.

Shasta red and noble fir were used for the first time in direct seeding trials during October 1954 on the Rustler Peak sale area of the Rogue River National Forest. Seed was broadcast on a 30-acre clearcut and grain treated with 1080 was distributed in advance for rodent control.

Forest Measurement

Search for more accurate and more efficient methods for measuring trees, logs, or other wood products, and for estimating volume, growth, and mortality in forest stands continues to be a major activity.

Gross yields of Douglas-fir. Probably the outstanding contribution during 1954 was the development of a method for estimating normal mortality for fully stocked stands of Douglas-fir. For site II, annual losses per acre were found to total one-half cord at 40 years, 150 board feet (Scribner) at 70 years, and about 470 board feet (Scribner) after 100 years. Addition of cumulative mortality to net yield makes it possible to construct gross yield tables for Douglas-fir covering all sites and all ages up to 160 years. These will provide a measure of total yields obtainable under a plan of intensive management that would forestall or salvage all mortality through light and frequent thinnings. Among other things, the analysis shows that when full gross yields are utilized, culmination of mean annual increment occurs 20 to 30 years later than when only net yields are used. The technique was presented by Staebler in a paper at the annual meeting of the Society of American Foresters. Gross yield tables for all sites will be released as a Station paper during 1955.

"Standard Computations for Permanent Sample Plots" is the title of a report released late in December. This manual of instruction is a product of the Committee on Standardization of Growth Computation Procedures--a subcommittee of the Station's Puget Sound Research Center Advisory Committee. Use of this uniform procedure will permit pooling information and will facilitate comparison of data collected on growth plots in western Washington by various agencies and companies.

As a part of the committee's project, a search was made for a satisfactory mathematical expression of curve of tree height over diameter in even-aged stands. Although not completely satisfactory, a curve of the following type seemed to have the fewest disadvantages:

$$H = a + bD + cD^2$$

where H is total tree height, D is diameter, outside bark, at breast height, and a, b, and c are constants.

Proper use of normal yield tables for Douglas-fir was more clearly defined through three related analyses. A test of five methods

for predicting future stand volumes of well-stocked stands was expanded during 1954 to include two additional methods. Superiority was maintained by the method based on the assumption that well-stocked stands will make normal growth. An article presenting the findings will be published in the Journal of Forestry early in 1955.

Stand age can also be more accurately estimated by a technique for removing a source of bias. Under the recommended procedure, which has been released as a research note, a slight correction is applied to average age of dominants to give stand age as defined in the normal yield tables.

An examination of the basic work sheets for the normal yield tables also revealed that average height of dominant and codominant trees (as used in site curve development) was the arithmetic average of the heights of several dominants and codominants. It has frequently been assumed that average height was the height of tree of average basal area. This finding has practical consequences in certain types of experimental work.

Growth in spruce-hemlock. New yield tables for western hemlock, developed by Dr. George H. Barnes of the School of Forestry, Oregon State College, will soon be available. Final revision is now under way following suggestions by a board of review, and publication as a USDA Technical Bulletin is planned for 1955.

Remeasurement of four sample plots in the spruce-hemlock type gave varying results. Two stands now about 110 years of age were found to be disintegrating rapidly and had lost cubic volume at the rates of 160 and 250 cubic feet per acre annually during the last 10 years. Windfall had caused most of the mortality. Two other stands now age 60 gained volume at the rates of 250 and 300 cubic feet per acre annually during the same period. In the younger stands, losses were about normal and mean annual increment is still on the rise.

Ratio of bark thickness to tree diameter (outside bark) was found to be 13.7 percent for Douglas-firs of all ages and sizes. Based on 479 sets of tree measurements from widely scattered localities, this ratio should prove helpful in estimating past diameters of trees in certain types of growth studies.

Volume tables for Pacific Northwest trees, assembled during 1953, were submitted during 1954 to the Washington Office of the Forest Service and will be published during 1955 as a USDA Agricultural Handbook.

Volumes of individual 16-foot logs of western conifers were also developed from the Bruce and Girard form class tables during 1954. These log position volume tables should be useful in estimating timber volume by log grade as well as in eliminating the volume of cull logs from gross-cruise estimates.

Brush Control

Studies in chemical control of brush species that hinder regeneration of conifer seedlings are a recent addition to the Station's program. First started at the Cascade Head Experimental Forest in 1952, exploratory tests of chemical sprays were extended during 1953 to problem brush species in southwest and central Oregon. Interest has centered on the effect of candidate sprays on both broadleaved brush and commercial conifers.

In central Oregon, 100 percent kill of nonsprouting manzanita was obtained with only one pound per acre of 2,4-D (acid equivalent) in three gallons of an oil-water emulsion carrier. The spray, formulated with a low volatile ester of 2,4-D was applied to a brush field on the Deschutes National Forest from an airplane. Cost of killing manzanita in this pilot-size trial was $2.80 per acre, including $1.55 for materials and $1.25 for application. The study demonstrates that chemical control holds real promise as an effective and inexpensive method for restoring the extensive brush fields of central Oregon to forest production. In this area, spraying can apparently be used to advantage both for releasing natural seedlings that are suppressed by brush and for preparing brushy sites for seeding or planting.

In southwest Oregon, exploratory trials showed that Port-Orford-cedar is less susceptible to damage from 2,4-D and 2,4,5-T than Douglas-fir, western white pine, and sugar pine. Sapling size trees were sprayed with the two herbicides alone and in combination at three concentrations varying from 2.4 to 7.4 pounds (acid equivalent) per 100 gallons of water. Solutions were applied at the rate of 150 gallons per acre. No Port-Orford-cedars were killed by the treatments and their vigor was only slightly impaired. For other species, some of the trees were killed, many showed killing of old foliage, and current year's foliage was killed wherever it was directly exposed to the spray. Damage to Douglas-fir and the pines increased when the more concentrated solutions were applied. Smaller trees of these species were more seriously damaged than larger ones.

A comprehensive review of brush control literature and experience was completed during 1954 and a selected bibliography prepared. A summary of this information will be released early in 1955 as a Station research paper. The summary will cover control by chemical, mechanical, and biological means as well as by fire, and will emphasize methods that hold promise for control of problem brush species in Oregon and Washington.

Fire Studies

Development of improved methods for predicting fire weather and burning conditions is a matter of real concern to Federal, State, and private foresters who are jointly responsible for protecting 54 million acres of forest land in Oregon and Washington. The Station has tested

several alternative methods for predicting wind speed and fuel moisture at specific localities. These tests have demonstrated some major weaknesses in current predicting methods. So far, however, they have failed to uncover promising leads for new methods that would be simple and sufficiently accurate for day-to-day fire control planning.

Wind speed. During two consecutive summers, the Weather Bureau furnished special forecasts of the 4:30 p.m. wind speed at 12 mountaintop stations in Oregon and Washington. Independent forecasts were also made based on:

1. Normal 4:30 p.m. wind speed for summer.
2. Actual 4:30 p.m. wind speed of preceding day.
3. Regular fire-weather forecast.
4. Observed 8 a.m. wind speed and direction.

Actual 4:30 p.m. wind speed was used for verification. Any forecast was rated correct if within specific limits of actual speed. On this basis, spot forecasts by the Weather Bureau were found to be correct on only 60 percent of total days studied. The spot forecasts were less accurate for days that would be of special concern to fire control men. For days of high burning index, spot forecasts were correct 50 percent of the time, for days when wind speed changed markedly from the previous day, 45 percent, and for days with wind speeds outside the normal range, only 40 percent. Sixty-five percent of days had normal winds and 55 percent had the same speed as the previous day. Apparently intensive study of wind characteristics and wind dynamics in mountainous terrain will be needed before more accurate prediction methods can be developed.

Fuel moisture along with wind speed is used in the Pacific Northwest to determine burning index. Various methods of predicting 4:30 p.m. fuel moisture were tested for high and low elevation fire danger stations on five ranger districts. The records covered two summers and four prediction methods were tested. For low elevation stations the analysis that the persistence method--assuming tomorrow's fuel moisture or relative humidity will be the same as today's--provided a prediction as good or slightly better than other methods. For stations on mountain peaks, however, afternoon fuel moisture was most accurately predicted by using the previous afternoon's relative humidity and the current morning's fuel moisture. The analysis emphasizes the need for concentrated research on sampling and weather prediction in mountainous terrain.

Seasonal fire-weather index for 1954. For the second successive year, forest fire weather in western Oregon and Washington was far below normal severity. The Station's method of annual ratings is based on total number of rainless days, average number of days since a wetting rain of one-fourth inch or more, and burning index. Although fire weather was near normal during spring and fall, a rain-producing weather

pattern persisted from late May to mid-September. The result was a summer fire danger as low as any on record. In addition, fewer lightning storms occurred over national forests of western Oregon and Washington than in any year since 1950.

Accidental slash fires. Analysis of accidental fires that started in slash on national forests in western Oregon and Washington over the past four years showed that most were caused by logging. Of 88 fires that burned entirely in slash, from time of origin to time of attack, cause, in percent, was:

	Percent
Logging equipment, logging operation, or smoking by loggers	60
Smoking (other than loggers)	14
Lightning	10
Other	16

Time from origin until first attack was nearly the same for all man-caused fires. Logging fires were spreading faster, however, and were several times larger when first attacked than fires from other causes. Number of men in the first attacking force averaged 11.6 for logging fires and 5.9 for other man-caused fires. Bulldozers were more frequently used on the logging fires; but when finally controlled, logging fires averaged 710 acres compared to 23 acres for other man-caused fires, and only 3.7 acres for lightning fires. Possibly logging fires became larger because they started in fresher and more inflammable slash than slash fires from other causes.

Costs of Logging

Detailed logging costs have been collected as a part of the Station's pilot-plant harvesting experiments. These are providing a much-needed backlog of information on relative costs of various methods of harvesting and different types and combinations of equipment.

Production and costs in high-lead yarding was the subject of an intensive time study at Cascade Head under the leadership of Magnus Tennas, a research forester from Norway, and in cooperation with the School of Forestry, Oregon State College. The setting studied was in a 100-year-old spruce, hemlock, and fir stand and was carried out to determine how basic factors such as yarding distance, volume per turn, slope, and volume per acre influence production and costs. Haul-in distance was found to be the most important factor, followed closely by volume per turn. The analysis resulted in a series of curves and tables that can be used for estimating yarding costs where similar equipment is used on timber of comparable size and age.

Commercial thinning vs. clearcutting. A recent comparison at Wind River indicates that felling, bucking, yarding, and loading costs

(per thousand board feet) are only slightly higher for commercial thinning than for clearcutting. Both operations were in a 110-year-old stand of Douglas-fir on similar topography. Tractors, in both instances, were used for yarding. Thinning was from below, taking one-third of the total stand in trees averaging 17 inches d.b.h. In contrast, average size of tree harvested in the clearcutting was 23 inches d.b.h. Average costs per thousand board feet were as follows:

Item	Thinning	Clearcut
Felling and bucking	$ 4.75	$ 4.14
Yarding and loading	5.98	4.92
Equipment repair	2.19	1.98
Total	$12.92	$11.04
Difference in favor of clearcutting		$ 1.88

These records are based on the harvesting of 713 M board feet by thinning and 2,178 M board feet by clearcutting.

Management of Old-growth Douglas-fir

Three major objectives of old-growth management studies are: (1) Establishment of regeneration following clearcutting, (2) reduction of windfall on exposed timber edges, and (3) maximum salvage of mortality in leave settings.

Regeneration. At Wind River a re-examination of four areas clearcut five years ago and varying from 6 to 40 acres in size shows that restocking is progressing satisfactorily in all cases. Average stocking is now 80 percent (4-mil-acre basis) and the range is from 60 to 94 percent. Neither size of clearcutting nor broadcast burning of slash following logging appears to have strongly influenced the amount of regeneration at the end of five years. A good cone crop in the fall of 1949 provided the main source of seed.

At the H. J. Andrews Experimental Forest, an investigation of soil temperatures on recent clearcuttings was continued and expanded. Temperatures were again measured by wax pellets which melted at 138° F., a temperature lethal to most newly germinated Douglas-fir seedlings. A systematic sampling of eight clear-cut tracts at elevations from 2 to 4 thousand feet gave the following results:

Years after logging and burning	Available seedbed exceeding 138° F.	
	North slopes (Percent)	South slopes (Percent)
1	23	83
2	34	52
3	28	60
4	26	48

In spite of a cool, moist summer in 1954, a high percentage of available seedbed on south slopes exceeded lethal temperatures. The proportion of untenable seedbeds on north slopes, though much less, was still appreciable. The wax pellets proved to be exceptionally well adapted to soil temperature studies of this kind. They are waterproof, accurate to one percent of the indicated temperature, and can be readily placed near the stems of germinating seedlings. They are, moreover, inexpensive and commercially available.

Windfall of Douglas-fir and its associated species was intensively studied around the borders of eight clearcuttings on the H. J. Andrews Experimental Forest. All windthrown trees along 8.9 miles of cutting boundary were examined and mapped. Analysis of windfall patterns and of individual tree records showed that for central Oregon Cascades:

1. Most hazardous winds come from the southwest, but east winds also cause appreciable windthrow.

2. Amount of windthrow is influenced by soil and stand conditions, species composition, local topography, and location of cutting boundaries. Combined effect of these factors seems to be far more important than size of clearcut.

3. Douglas-fir is more windfirm than western hemlock, and hemlock more windfirm than Pacific silver fir. On dry sites, western redcedar seemed to be the most wind resistant of all species.

4. Root and butt rots, in that order, were the main agents that increased susceptibility of old-growth Douglas-fir to blowdown.

5. Shallow and poorly drained soils increased windfall susceptibility of all species.

6. Timbered borders around staggered settings can deflect storm winds, concentrate windflow, and focus the force of accelerated winds on a small portion of the cutting border. Extensive blowdown may occur where the wind breaks into the timber.

Study units were all located on a general northwest slope. Under these conditions, cutting boundaries located parallel to the contour (usually along logging roads) sustained the least blowdown of Douglas-fir. Cutting boundaries along secondary ridges, perpendicular to the contour or along creeks, were most susceptible to wind damage. These relationships suggest a number of ways in which windfall damage can be reduced through improvements in the layout and design of cutting units.

Salvage of mortality. Construction of access roads on both national forest and private land is increasing each year. These roads

provide an excellent opportunity for salvaging dead and dying material from timber stands opened up but not scheduled for clearcutting in the near future. The problem is to yard logs economically and without undue damage to the soil or the residual stand. Many leave settings are on steep topography. A study initiated last fall on the H. J. Andrews Experimental Forest will test one promising salvage method. Logs will be cable-yarded uphill to existing rocked roads and to low-standard spur roads constructed about halfway between existing road levels. A portable yarder-loader will be used for both yarding and loading. Under this scheme, the salvage operation will cover a strip 400 to 500 feet wide between roads.

A measure of timber volumes recoverable through salvage logging was furnished by a 6-year record of permanent plots on the 1,140-acre Wind River Natural Area. In this 350-year-old stand, mortality averaged 759 board feet per acre annually and three-fifths of this volume loss was in old-growth Douglas-fir. Although total volume of the stand changed only slightly during the 6-year period, the subclimax Douglas-fir is gradually losing ground to the more tolerant species--western hemlock, Pacific silver fir, and western redcedar. Mortality was sporadic and unpredictable with bark beetles and mistletoe the leading causes. Windfall was relatively light. An estimated 80 percent of the total mortality, or 607 board feet per acre, could be salvaged annually. Total yields from reserve Douglas-fir settings obviously can be increased substantially by this means.

Management of Young-growth Douglas-fir

Studies of various cultural practices and different kinds and degrees of commercial thinnings are under way in young Douglas-fir stands varying in age from 10 to 150 years. Most of this work is under the direction of the Puget Sound Research Center.

Precommercial thinning. Evidence continues to indicate that considerable usable increment is lost in fully stocked Douglas-fir stands if thinnings are postponed until the operation can pay its way. A spacing-increment study started last year at the Wind River and Hemlock Experimental Forests assumes that the best spacing in reproduction stands is one that permits all trees to make maximum diameter growth until they reach minimum commercial size (in this case, sawtimber). The study is designed to determine how many trees should be retained per acre when only one precommercial thinning is anticipated. Six stand densities, varying from 50 to 350 trees per acre, are under test.

In the Wind River installation, 1954 leader growth was markedly reduced following heavy thinning the previous fall. In unthinned portions of the 25-year-old plantation, 1954 leader growth averaged one inch less than in 1953. Under the six degrees of thinning, in contrast, leader growth was 9 to 15 inches less in 1954 than in 1953. Observations will be continued to determine how rapidly trees in the various spacings recover from this initial shock and regain normal growth.

Commercial thinning. The Kugel Creek plots near Forks on the Olympic National Forest, though destroyed by fire in 1951 and later abandoned, demonstrate the value of early field trials and long-term observation and analysis of thinning methods. The stand was thinned and pruned in 1937 at age 38 years. The 14-year record shows that:

1. At least 25 cords per acre may be cut from a 38-year-old Douglas-fir forest (well stocked, site II) without lowering net growth--in fact, board-foot growth was substantially increased.

2. Through thinning, growth can be concentrated on quality trees.

3. Fire damage in thinned and pruned stands was far less serious than in unthinned stands.

Studies at the Voight Creek Experimental Forest demonstrate that repeated light thinnings can be profitable in 40-year-old Douglas-fir on site II. In cooperation with the St. Paul & Tacoma Lumber Company, one 17-acre compartment was thinned a second time and another for the third time. In the second thinning (6-year cycle) 3.6 cords of pulpwood and 1,543 board feet of saw logs were harvested per acre at a stumpage return of $24.05. The third thinning (3-year cycle) took out 2.3 cords of pulpwood and 243 board feet of saw logs per acre at a return of $6.95. A contract crew of three men cut and skidded the material to roadside with a single horse. Pulpwood and logs were loaded by fork lift and trucked to plant by a second contractor. The cutting contractor preferred operating in stands previously thinned even though the cut per acre was lower. Skidroads were already in and better spacing of the trees simplified felling.

On the McCleary Experimental Forest, six years of experience in light frequent cuttings demonstrates that 90 percent of all mortality in 60-year Douglas-fir can be salvaged at a profit. In this cooperative study with the Simpson Logging Company returns from annual salvage alone are paying for 62 percent of all road construction and maintenance costs on a 200-acre area. An average of 115 board feet per acre have been salvaged annually from the thinned areas at McCleary. Salvage of 200 board feet per acre each year would be sufficient to cover all the road development and maintenance costs.

At Wind River, trials of commercial thinnings in 110-year-old Douglas-fir have been under way more than 10 years. Analysis of skidding damage under a 40 percent and a 25 percent cut was made during 1954. Only one percent of the circumference of the remaining trees was found to be damaged under both treatments. Bark damage was low because skid trails were constructed ahead of felling and trees were felled toward the lead of these trails. Removal of smaller trees in the stand and late-summer skidding when bark had started to tighten also contributed to low stem damage. An average of three trees per acre sustained root damage during skidding in the 40 percent cut compared to one tree

per acre in the lighter cut. The difference is attributed to more tractor trips per skid trail in the heavier thinning.

Ponderosa Pine Management

The Round Mountain Experimental Management Block was officially approved early in 1954 and preliminary plans for its management and administration have been drafted. The area covers 25,400 acres adjoining the Pringle Falls Experimental Forest and contains 330 million board feet of timber. Two pilot-scale trials will be undertaken. One will test the application of all-aged management and silviculture in ponderosa pine. The second will test the application of even-aged management. The experimental block will be operated jointly by the research and administration branches of the Forest Service and will serve as a testing ground for research information and for determining the intensity of forest practice now practical in managing ponderosa pine.

Pine seedlings and grass. Seeding grasses as an erosion control measure on areas disturbed by logging has been questioned because the grass cover may hinder re-establishment of pine seedlings. One possible solution being tested on the Ochoco National Forest is planting pine seedlings in the first season after logging so they may have an even start with the seeded grass. The Station is cooperating in the study and will compare the survival of planted trees with and without competition from grass. The small clear-cut unit which serves as a site for the study holds special interest because it also represents an attempt to convert a ragged overstory stand of defective white fir with a dense understory of the same species to a productive stand of ponderosa pine. If a usable cover of forage grasses can be grown together with pine seedlings, conversion will provide multiple gains.

Growth of released pole-size pine was investigated by Gillmor and Jones of the Fremont National Forest. They found that average diameter growth rate of young pines more than doubled after heavy logging of overstory trees. Thus many young trees considered too slowgrowing for pruning at time of logging are potentially good crop tree selections.

Thinning. The first trial of prescribed burning as a thinning practice in dense sapling stands was initiated by the Office of Indian Affairs on the Colville Reservation in 1942. Since 1950, the Station has cooperated in the remeasurement and analysis of data from the 21-acre tract. During the first seven years, crop trees on the burned area made greater height and diameter growth than comparable trees on the unburned plot. However, 13 percent of the crop trees on the burned plot died during this period compared to only 3 percent on the unburned. The difference is attributed mainly to losses resulting from fire injury. At the end of seven years, 22 percent of the surviving crop trees on the burned plot still showed fire scars.

Possibility of chemical thinning, using 2,4-D, is also being studied at Pringle Falls. Trees as large as 3½ inches d.b.h. were

killed by squirting 4 cc. of amine 2,4-D into a hack mark made with one stroke of a hatchet. More hacks are required for larger trees. Further trials are planned to determine minimum treatment required for various sized trees, effect of dying trees on insect populations, and costs of chemical thinning.

Commercial thinnings in even-aged ponderosa pine can be expected to increase total yields substantially above values in the normal yield tables according to calculations for a 105-year stand at Pringle Falls on site III. A first intermediate cut of 5,000 board feet (Scribner) per acre was made in 1950 in a stand containing 201 trees per acre with a total volume of 31,000 board feet. Projection of current stand development indicates that three additional thinnings of about the same volume can be made before final harvest at stand age 180 years. Final per acre harvest is expected to consist of 45 favored crop trees with a total volume of about 50,000 board feet. This would equal the normal yield for fully stocked stands at 180 years on site III. If these calculations are correct, the four intermediate thinnings would boost total yields to 70,000 board feet--a gain of 40 percent above normal. An even greater gain might be anticipated if commercial thinnings had been initiated at an earlier age.

Lodgepole Pine Management

Lodgepole pine has received relatively little attention in the Station's program but a special study was made during the fall of 1954 on seed retention characteristics of cones in central Oregon.

In many parts of its wide range, lodgepole retains viable seed in closed persistent cones for a number of years. Following logging, cones in the slash open and discharge their seed, thereby providing an ample and well-distributed supply of seed following clearcutting.

In central Oregon, the closed-cone characteristic has been questioned, however, because older cones were observed to be well opened during dry periods. A systematic check on seed persistence was made on trees of several ages and under a variety of stand conditions in the Deschutes Basin. Stands sampled ranged in elevation from 4000 to 6400 feet.

Although cones were found to hang on for 25 years or longer, only the 1954 cones contained sound seed. This indicates that extensive clearcuttings should be avoided in central Oregon if natural regeneration of lodgepole pine is desired following logging. One exception might be a clearcutting timed to take advantage of a good seed crop from the current year's cones. Otherwise, a source of seed should be provided in the form of reserved trees or closely adjacent stands.

Spruce-Hemlock Management

Investigations in the highly productive coastal forests of spruce-hemlock are concentrated at the Cascade Head Experimental Forest

on the Oregon Coast and at the Hemlock Experimental Forest near Gray's Harbor, Wash. Commercial thinnings in 50-year stands are under trial at the Hemlock Experimental Forest in cooperation with St. Regis Paper Company. At Cascade Head, both harvest cuttings and commercial thinnings are being tested in a 100-year-old stand.

Progressive strip cutting was put into trial for the first time during 1954 at Cascade Head to determine its advantages and limitations in comparison with the staggered-setting scheme of cutting now in general use. Principal objective in applying the method will be to minimize wind damage by eliminating north and east cutting boundaries which are most susceptible to southwest storm winds. Starting with a natural opening near the north boundary of the forest, cutting will progress into prevailing storm winds. Evaluation of the system will be based on seed fall, regeneration, slash disposal, and logging costs, in addition to blowdown. That wind damage is a major forest problem in the coastal type was strikingly demonstrated by the storm of December 4, 1951, which leveled an estimated 3.7 billion board feet of merchantable timber in a few hours.

Seed fall. Four years of seed-fall measurement at Cascade Head indicate that clearcutting by the staggered-setting system can be depended upon to provide an ample, well-distributed seed supply. The largest of six clear-cut tracts sampled (81 acres) received 243,300 viable spruce and hemlock seed per acre annually on a high ridge near the center of the area. This information indicates that it may be practical to cut fairly large openings in spruce-hemlock forests and still depend on adjacent stands for windborne seed supply. During 1951 and 1952, average annual seed fall on all six clear-cut tracts was 352,000 viable seed per acre. Seed fall under nearby dense stands was 15 times greater. During the four-year period, seed fall always started during the last 10 days in October. Half of the seed crop was usually on the ground by mid-November and 90 percent by February 1. Species, areas, years, and proximity to the ocean all caused some variation in the period of seed fall.

Management of Mixed Conifers in Southwest Oregon

Nowhere in the Pacific Northwest are management problems more complex than in the mixed stands of the Siskiyou-Cascade problem area. Conditions of soil moisture and temperature as well as species composition vary tremendously within a distance of only a mile or two. Current research effort within this subregion is devoted primarily to the management of sugar pine with minor attention given to Port-Orford-cedar, Shasta red fir, Douglas-fir, and ponderosa pine.

Restocking conditions on older cutovers in the South Umpqua drainage and on slopes north of the upper Rogue River were investigated in a survey completed late in the year. Altogether, 2,440 four-mil-acre plots were examined on 61 sample cutovers. If all commercial conifers are accepted, 42 of these cutovers would rate well stocked (70 percent or over), 14 medium-stocked (40-69 percent), and 5 poorly stocked (10-39 percent). No cutovers showed a stocking under 10 percent. Two-thirds of the stocked plots were occupied by trees that followed logging

and one-third by trees established before logging. Douglas-fir was the dominant species on 62 percent of the stocked plots. Sugar pine and ponderosa pine accounted for another 10 percent. The remaining 28 percent of the stocked plots were dominated by species presently considered of secondary desirability. These include western hemlock, incense cedar, western redcedar, lodgepole pine, knobcone pine, and true firs. The regeneration problem in this area is apparently one of getting the right species established rather than a deficiency of conifer seedlings.

Increasing effectiveness of natural seed fall through rodent poisoning was tested on the Junction Springs sale area of the Umpqua National Forest. Partial cutting on a 12- and a 20-acre area in 1953 left only ponderosa pine and sugar pine. Reserve pines produced a medium seed crop that fall, but trapping in late August showed that both areas supported a light rodent population. The smaller unit was treated with 1080 in early September, with thallium sulfate in December and again with 1080 in April 1954. Although seed fall was about the same on both areas (roughly 90,000 seed per acre), almost four times more seedlings germinated on the treated area. At the end of the first growing season, the treated area was 73 percent stocked (mil-acre basis) compared to 49 percent on the untreated. The bulk of the seed and seedlings was ponderosa pine. It is apparent that control of rodents by 1080 and thallium holds real promise for improving regeneration from natural seed fall. Further tests are needed to explore the influence of these treatments with lighter seed crops and heavier rodent populations.

Pruning young sugar pine to remove blister rust infections has been tested on a sizable scale on the South Umpqua Experimental Forest. Altogether some 4,600 potential crop trees in the 30- to 40-year age class were pruned under contract during 1953 and 1954. All trees are in a blister rust control unit from which all shrubs of the genus Ribes were first eradicated in 1947-48 and re-eradicated in 1953-54. Late in 1954, 20 percent of the pruned trees were carefully checked to determine success of canker removal in a contract operation. Pretreatment sampling showed that 63 percent of potential crop trees were infected. After pruning only 6 percent of the crop trees were found to be infected. Many of the missed cankers were small and obscure. The initial results are considered reasonably successful, but a second examination for new and missed cankers is planned for 1957.

Natural regeneration of Shasta red fir has been studied on one 35-acre clearcutting on the Rogue River National Forest. The area was logged and slash burned in 1951, and the surrounding timber stand bore a good crop of seed in 1951 and again in 1953. By the fall of 1954, 42 percent of the mil-acre plots were stocked with third-year seedlings of Shasta red fir, and an additional 30 percent were stocked with first-year seedlings. For the older class of seedlings, survival over the previous 12 months was 85 percent. About two-thirds of the seedlings germinating in 1954 survived the first growing season. Seedlings of other species--mountain hemlock, western white pine, and incense cedar--are

present on the area, but they occur in very small numbers. All evidence from this one cutting indicates that Shasta red fir is well adapted to clearcutting by the staggered-setting system.

Plans for Forest Management Research in 1955

No major change in the general scope and direction of the forest management program is anticipated during 1955, but the following tasks will receive special emphasis:

1. Analyze and publish a large backlog of information in practically all major research projects.
2. Initiate a full-scale research attack on brush-control problems in southwest Oregon.
3. Cooperate with the Regional Office of the Forest Service in the establishing of two demonstration seed-collection areas and in developing improved inventory procedures for working-circle surveys.
4. Complete current analysis of data from the series of method-of-cutting studies in ponderosa pine.
5. Complete first draft of a USDA circular on management and utilization of red alder (in cooperation with Forest Utilization Service) and develop plans for a Departmental publication on commercial thinnings in young-growth Douglas-fir.

FOREST DISEASE RESEARCH

This division studies diseases affecting forest nurseries and plantations; diseases and decays of forest trees; stains and decays of wood products and of fire-killed, insect-killed, and windthrown timber; and deterioration of logging slash. It devises methods for control of diseases and decays, and assists in development of salvage programs.

Recent appointment of a forest disease research subcommittee of the Northwest Forest Pest Action Committee is expected to greatly assist in stimulating and coordinating work in this field.

Little is known of the magnitude of damage attributable to forest diseases in this region. As a start towards remedying this deficiency, a table of preliminary estimates was prepared in 1954, based on the best available information, of the average annual volume and financial loss caused by the various groups of diseases to the principal commercial timber species in the two principal subregions of the Pacific Northwest.

During 1954, studies of blister rust on sugar pine were started in southwestern Oregon. A systematic survey of the Phytophthora root

rots of Port-Orford-cedar was made in cooperation with the State Forester of Oregon, the Oregon State Department of Agriculture, and the Oregon State College Forest Experiment Station. Major emphasis was placed on continuing the survey of Poria weirii root rot of Douglas-fir. Summaries of these and other activities follow.

Nursery and Plantation Studies

Rhizoctonia damping-off. At Wind River, damping-off losses were unusually heavy in parts of the nursery. Fair control was obtained by the use of Douglas-fir sawdust and aluminum sulfate applied just before spring sowing. Sulfite liquor and Orzan (a product containing sulfite) gave unsatisfactory control. Tests are being repeated increasing the aluminum sulfate strength. Copper sulfate and Bordeaux and Semesan dusts were applied in an effort to control damping-off while in progress, but all failed to check the losses and the copper sulfate caused acid damage.

Fusarium root rot. Because of unusually heavy damping-off losses of ponderosa pine seedlings in check beds at the Bend Nursery, the soil amendment treatments used showed much more favorably than in previous tests. All treatments exceeded the checks considerably, the best survival being given by the following:

Fall application, 1953	Survival better than checks (Percent)
Aluminum sulfate - 3 oz. per sq. ft.	471
Ferrous sulfate - 3 oz. per sq. ft.	375
Ponderosa pine duff and aluminum sulfate 2 oz.	304
Aluminum sulfate - 2 oz. per sq. ft.	275
Sawdust 10 tons per acre + aluminum sulfate 2 oz.	262
Spring application, 1954	
Sawdust + fertilizer 200 lb. + aluminum sulfate 1 oz.	619
Ferrous sulfate - 2 oz. per sq. ft.	597
Aluminum sulfate - 2 oz. per sq. ft.	585
Sawdust + fertilizer + ferrous sulfate 1 oz.	555
Sawdust + ferrous sulfate 1 oz. per sq. ft.	511

Ammonium phosphate fertilizer and ponderosa pine sawdust were used. Arasan, Fermate, Ceresan, and Semesan dusts were also tried after emergence to control damping-off. The first two of these showed promise.

Mycorrhizal studies. Mycorrhizal fungi appear to come back gradually after burning. Apparently it takes natural Douglas-fir

seedlings at least two years on burned soil to reach the same stage of mycorrhizal development as one-year-old seedlings on unburned land. Meanwhile there is a greater probability of loss on burned soil because of reduced mycorrhizal development. This factor, ordinarily not considered, may be important in artificially reseeding burns. These findings were from a cooperative study with the Division of Forest Management Research.

Foliage Diseases

Needle cast of Douglas-fir Christmas trees. Heavy losses during harvesting and shipping of Christmas trees occurred during the 1953 season, and moderate losses during the 1954 season, in the Puget Sound area. It is evident that these losses were not caused by either of the two needle-cast fungi that are common on this host at times. Some operators tried spraying the trees with fungicides but results are not yet known. Interest is not now strong enough to support a sustained research program on the problems accompanying the harvesting and shipping of Christmas trees in this region.

Needle blight of ponderosa pine. Re-examinations of permanent plots on the Ochoco and Malheur National Forests furnished additional evidence supporting the conclusions summarized in last year's report. Results have been prepared for publication. Because of conflict with other projects during the season when this disease is most conspicuous, the show-me trip for pine foresters was postponed to 1955.

Stem Diseases and Decays

White pine blister rust. Upper and lower limits of 490 cankers on sugar pine twigs of various sizes in four localities were marked with paint, detailed data were taken, and canker growth measured near the end of the growing season. Information on the survival and rate of growth of these cankers, as determined by periodic remeasurements over several years, will permit prediction of rate and extent of damage by the rust in young stands where it became established before ribes eradication.

Preserved material from 68 cankers was studied microscopically to determine extent of rust mycelium beyond the microscopically visible limits of the cankers. Results from material collected in the fall indicate that mycelium rarely extends more than about an inch beyond the discolored bark, and that pruning of infected branches will protect the tree if the cankers are at least an inch from the trunk. This study is cooperative with the Siskiyou-Cascade Research Center.

In an effort to protect sugar pine nursery stock from blister rust infection, Fermate spray was applied at Wind River. This study is in cooperation with Blister Rust Control of Region 5, Gifford Pinchot National Forest, and Region 6 Division of Timber Management.

Ponderosa pine mistletoe. At Pringle Falls, studies of patterns of spread were continued, and studies of damage by the parasite were started, in cooperation with the Deschutes Research Center, the Oregon State Forestry Department, and the Oregon State College Forest Experiment Station. Two seasons of direct measurement of mistletoe seed dissemination have substantiated previous indications of limited spread. From an isolated overstory tree, seed dissemination conformed closely to the distribution of infection in understory stands--an elliptical area with a maximum dissemination distance of 132 feet downwind. In a virgin stand with seed source nearer the ground, seed was thrown to a maximum distance of 15 feet. In a dense young pole stand dispersal was very limited, only one seed being caught more than 6.6 feet from the limit of infestation while 158 seeds were caught just within or at the edge of the infected area. A lower stand density permitted somewhat wider dissemination. Data from the damage study have not yet been analyzed.

In cooperation with the Deschutes National Forest, three experimental control plots, one of 30 acres and two of 11 acres each, were established in a severely infected stand. Data were taken on adequacy of stocking with advance reproduction, and on intensity of infection. After complete removal of the overstory, the first plot will be burned and planted, the second will have all infected reproduction removed, and the third will be untreated. Cost records will be kept during the cleaning operation on the second plot. Periodic examinations will be made to determine the effectiveness of control on the first two plots, and the amount of increase or decrease of infection on the third plot. Preliminary results should be available in about 15 years.

Esters of 2,4-D and 2,4,5-T were again used as sprays in water dilutions of 0.10 percent and 1.0 percent strength. Sprays were applied directly to mistletoe plants on ponderosa pine saplings, and to the bases left after the shoots were removed. In most instances the mistletoe shoots were destroyed, but invariably new shoots appeared next season. There is no doubt, however, that spraying with most of these compounds definitely interferes with production of mistletoe seed for two seasons at least. The tests will be continued using other compounds and trying dilution with oil. This study is in cooperation with the Deschutes Research Center.

Decay of beetle-killed Douglas-fir and silver fir. Work on Douglas-fir was delayed temporarily by lack of dated trees in the 3- to 4-year mortality groups.

A preliminary study of 41 dated beetle-killed silver firs was completed in cooperation with the Division of Forest Insect Research, Puget Sound Pulp & Timber Co., Weyerhaeuser Timber Company, and the Mt. Baker National Forest. Beetle-killed silver firs are rapidly invaded by wood-rotting fungi. The most common decay found was brown cubical rot caused by Fomes pinicola. The shoestring fungus, Armillaria mellea, was present to some extent in bases of all trees examined. Little consistency was found in rate of decay. The most important cause of the

variation is patch-killing of portions of the stem, due to past intermittent beetle infestations. Trees dead 2 years lost 8 percent of their cubic-foot volume from decay, those dead 3 years lost 15 percent, and trees dead 4 years lost 19 percent. These figures include only the rot following beetle infestation. Additional losses resulted from broken tops, butt rots, and breakage in falling. Further studies will be made as soon as beetle-killed trees can be dated.

Root Diseases

Poria weirii root rot of Douglas-fir. On a 15-acre clearcut in a 112-year-old stand on the Gifford Pinchot National Forest, the percentage of living trees having infection visible on the stump was found to vary inversely with distance from the nearest tree killed by the disease. Within 10 feet, 88 percent of the trees were infected, while only 4 percent were infected at distances greater than 50 feet. Infection also tended to be visible most frequently in the portion of the stump towards the nearest killed tree. These observations are consistent with previous studies and with known vegetative spread of the disease from tree to tree. However, for some unknown reason, the average extent of decay within infected trees showed no correlation with distance from the nearest killed tree. The relatively few cultures obtained from this clearcut showed that the disease had spread from several distinct centers, most of which were undoubtedly active in the preceding stand. From one of these centers the disease had extended over about an acre and a half on the study area, plus an undetermined acreage in the adjoining stand. On the study area, spread from this one center had resulted in the death of 42 trees of sawtimber size, and the infection of 36 of the 177 trees still alive within the infection center.

The Poria weirii surveys showed that: (1) On a half-section of mixed Douglas-fir and other conifers on the Gifford Pinchot National Forest, 4.1 percent of the stand was found to have been destroyed. The disease was previously believed to be destructive only in nearly pure stands of Douglas-fir. (2) Approximately 10 percent of a stand of pole-sized timber, over an area of 1,095 acres on the Olympic National Forest, was found to have been destroyed. Damage appeared equally severe over at least another thousand acres (not surveyed) adjacent to the surveyed area. Distribution of the disease in this stand is such that productivity over the full rotation will probably be reduced about one-third. (3) The disease was found to be common throughout a 244-acre block surveyed in a plantation 27 to 28 years old on the Olympic National Forest. Damage to date has been slight, but it is evident that heavy losses will occur, both in the surveyed area and elsewhere in the plantation, before the stand reaches commercial maturity. This situation indicates a need for reconsideration of planting policy on areas where P. weirii is abundant. (4) It is becoming increasingly obvious that one of the most important and difficult problems connected with this disease is an evaluation of the factors governing its erratic distribution.

Phytophthora root rots of Port-Orford-cedar. Parts of southwestern Oregon were covered by a survey of Phytophthora lateralis, in

cooperation with the Oregon State Department of Agriculture and the Siskiyou-Cascade Research Center. Within the natural range of Port-Orford-cedar, the disease is confined to an area from about 35 miles north to 60 miles south of Coos Bay, and from the ocean to about 8 or 10 miles inland. Research on the disease is being conducted by the Oregon State College Forest Experiment Station, in cooperation with this division.

Decays and Stains of Forest Products

On-the-job treating tests. No decay is yet evident in either the rails or flooring units, but the paint is scaling badly on some units.

Penetrability studies. This work has been finished. Results clearly indicated an appreciable increase of penetration of preservative in molded Douglas-fir posts. The Oregon Forest Products Laboratory, utilizing our unused test material, found that soaking in hot-cold baths and pressure treatment resulted in twice the penetration of preservative. Penetration was more uniform, as well as greater, in molded as compared to mold-free posts.

Prevention of decay in stored logs. To determine whether sprinkling of cold decks retards decay, a study was undertaken at the request of the Oregon Pulp & Paper Co., and in cooperation with this company and the Forest Utilization Service. Eighty western hemlock logs of various diameters were selected from the normal log supply at the mill, sawed in half, and the halves placed in separate decks, one of which was sprinkled from July 1 to mid-December. Some of the logs were sound and green when decked, while many were older and already contained decay. Sections were cut from the ends of the green logs, and from the ends and centers of the older logs, and were stored at the mill for future reference. Complete notes on deterioration and defects were also taken. One-half of each pile is to be taken down and the logs examined for extension of decay this spring. The other half will remain decked for the two-year duration of the test.

The logs in the watered deck are now covered with a black slime-like growth. The unwatered deck shows no such slime growth but a good deal of checking of the log ends has taken place, especially on the south side of the pile. The only evidence that decay has been active in the cold-decked logs was shown by the development of fresh sporophores of Lenzites saepiaria. These occurred more frequently on the unwatered logs.

Plans for Forest Disease Research in 1955

Regular projects will be continued as in the past, with the following additions or changes in emphasis:

1. Additional effort on nursery and plantation diseases, particularly the latter.

2. Work on needle blight of ponderosa pine will be expanded slightly.

3. Additional tests of silvicultural control of mistletoe will be started during the next few years. This pest is considered by many to cause the most destructive disease of ponderosa pine in this region. Since several decades will be required for completion of the tests it is urgent that they be started immediately.

4. Further investigations of heart rots in second-growth Douglas-fir will be made as time permits.

5. Expansion of work on Poria weirii will be principally in young stands, where the future importance of the disease will be greatest.

6. Unusually large volumes of timber have been killed by beetles and windthrow in this region since 1950. Considerable time must be spent during the next few years in determining deterioration rates of this material, as a guide to efficient salvage.

FOREST INSECT RESEARCH

During 1954, work of the Division of Forest Insect Research was integrated into the Station program with no material change in activities. Work on research, surveys, and control continued without interruption. Research efforts were concentrated upon the spruce budworm, Douglas-fir beetle, silver fir beetles, and survey techniques. Insect surveys were marked by continued and increased participation by cooperators. For the sixth consecutive year, aerial spraying against the spruce budworm was the principal control activity.

Increased funds make it possible to employ two additional men, one for biological control studies and one for survey techniques studies.

Forest Insect Surveys

Forest insect outbreaks in Oregon and Washington in 1954 were detected and evaluated by means of three cooperative surveys.

The regular aerial and ground survey of the 48 million forested acres in the region was cooperatively conducted with the Oregon State Board of Forestry, Washington State Division of Forestry, and many public and private foresters. Epidemic infestations were recorded on 7,704,120 acres, or about 16 percent of the region's forest land. A report presenting the principal findings was prepared and given general distribution. The report was reviewed by the

Northwest Forest Pest Action Committee at its annual meeting on November 1, 1954, and was the basis for their recommendations for control in 1955.

A special survey of the epidemic of silver fir beetles causing severe losses of Pacific silver fir in western Washington was made cooperatively by members of the Silver Fir Beetle Sub-Committee of the Northwest Forest Pest Action Committee. Results of this survey and work of the sub-committee in 1954 were summarized in a report presented at the annual meeting of the Pest Action Committee.

Aerial rephotography of 75 plots in the Douglas-fir region provided data on the status of the Douglas-fir beetle outbreak and the amount of timber killed by this insect. The data have been partially analyzed and a summary has been prepared. A more detailed report will be issued in the near future.

Spruce Budworm Studies

Studies in 1954 included: (1) Re-evaluation of budworm populations on areas sprayed in 1949 and 1950 to determine the lasting benefits of artificial control, (2) investigations of the long-term effects of spraying upon insect parasites of the budworm, and (3) investigations on unsprayed areas to determine the effectiveness of parasites in natural control of the budworm.

Study plots in eight centers of infestation have been examined annually since 1949 and 1950 to determine the long-term effects of aerial sprays of DDT upon the spruce budworm. Again in 1954, few budworm were recovered from the study plots, which indicates that control, properly applied, is effective up to five years after treatment.

The percentage of parasitism in the overwintering stage of the budworm was determined for the eight sprayed areas mentioned above and found to be an important part of the total parasitism of the budworm. In 1954, as in every year since spraying, parasitism of overwintering budworm larvae on many of the eight areas was equal to or greater than average parasitism on unsprayed areas. From this it is concluded that spraying has no harmful effect upon some of the principal parasites of the spruce budworm.

Total parasitism on unsprayed areas remained at about the same level as in previous years. There was no evidence that natural control from parasitism would be sufficient to cause a general decline of the 1955 infestation. This is one of the important reasons why aerial spraying should be continued against the budworm in 1955.

Douglas-fir Beetle Studies

A total of 5,071,750 acres of epidemic infestation by the Douglas-fir beetle was recorded in 1954. Some 4,328,660 acres were in western Oregon and Washington and the remaining 743,090 acres were in the eastern

portions of the two States. Most of the infestation recorded in 1954 actually occurred in 1953, because trees killed in the current season usually cannot be detected until after the regular survey season, and often not until the following year.

The aggressive epidemic of this beetle, which developed in windthrown timber in the western portions of the two States and which has continued at a high level since 1951, declined considerably in 1954 in most of the affected area. However on some areas, particularly the Smith River drainage of the Oregon Coast Range, the infestation continued high. Total kill by the beetle and blowdown from 1950 to 1954 in western Oregon and Washington is estimated at 15 billion board feet. Salvage is nearing its anticipated peak, but is expected to continue at a high rate for many years. The most active current killing is in the Blue Mountains in stands repeatedly defoliated by the spruce budworm. In many drainages practically all the Douglas-fir of sawtimber size has been killed.

Research on the Douglas-fir beetle is being conducted cooperatively by the Station, the Oregon State Board of Forestry, and Weyerhaeuser Timber Company. This program is guided by priorities set up by the Northwest Forest Pest Action Committee and is coordinated through periodic work conferences.

An exploratory study was undertaken by the Station in 1954 to test correlation of stand density, blowdown, deviation from normal radial increment, and site quality with the incidence of killing by the Douglas-fir beetle. Although these data are yet to be analyzed, the blowdown factor appears to be highly significant as a cause of outbreaks.

Permanent mortality plots on Weyerhaeuser Timber Company lands in Coos County, Oreg., were examined in cooperation with company personnel. This study has been in progress since 1946 and is the first attempt to study the causes and follow the annual trend of mortality in Douglas-fir sawtimber stands. The plots were established during a period of endemic mortality and subsequently were followed through periods of heavy blowdown, heavy beetle-kill, and declining beetle-kill. Beetle activity now is approaching an endemic level. Results of these studies are scheduled for publication in 1954 through a Station release.

Station Research Paper No. 10 on the rate of deterioration of beetle-killed Douglas-fir was prepared in 1954 in cooperation with Weyerhaeuser Timber Company and the Division of Forest Disease Research. There was strong evidence that beetle-killed trees deteriorate faster than trees dying from most other causes. This adds weight to the general belief that the beetles are carriers of spores of wood-rotting fungi. Further highlights of the findings of the study are presented in the section on Forest Disease Research in this report.

Since the deterioration data collected to date only cover trees that have been dead from 2 to 6 years, a new supply of beetle-killed

trees was tagged in 1954 and reserved for long-term study. To determine the progressive rate of deterioration, some of the trees will be cut in alternate years as long as they contain merchantable wood.

Considerable time was spent assisting private and public land managers to evaluate Douglas-fir beetle outbreaks on their lands. In practically all cases recent windthrow had been heavy and was assigned as the primary cause of the outbreaks. Salvage logging, with emphasis on removing currently infested material, was the usual recommendation given to keep wood loss to a minimum and to effect some control of the beetles.

Silver Fir Beetle Studies

Pacific silver fir in western Washington has been extensively killed by silver fir beetles during the past six years. In 1954, forest stands on 652,230 acres were damaged by these beetles in the two States. This was a 17 percent increase of infested acreage over that of 1953. The intensity of infestation also increased.

A special survey by the Silver Fir Beetle Sub-Committee, participated in by Station and National Forest Administration, showed a total silver fir volume of 6,949 million board feet on the infested area. Of this total, 528 million board feet was recently dead, 1,332 million was high risk, and the remainder was low risk. A total of 448 plots was established by the cooperators to follow the annual trend of the outbreak and thus to provide information needed for determining salvage logging priorities.

Salvage on the most heavily affected areas is being pushed and good progress has been made. It is estimated that 147 million board feet of silver fir was logged in 1954 and that some 205 million board feet will be logged in 1955.

Studies of the beetles and the nature and rapidity of their attack were continued on the series of tagged-tree plots already established in northern Washington. Additional plots were installed by cooperators. Most of the research effort on the silver fir beetle problem went into a study of the rate of deterioration of the beetle-killed trees. This study was made cooperatively by members of the Silver Fir Beetle Sub-Committee. In general, it was found that Pacific silver fir should be salvaged within four years after killing. A preliminary report on the findings to date is being prepared.

Balsam Woolly Aphid Studies

In 1954, Pacific silver fir in southern Washington was found to be severely attacked by an insect tentatively identified as Chermes piceae, the balsam woolly aphid. A total of 129,920 acres was mapped as being infested by Chermes alone and an additional 146,240 acres was found to be infested by Chermes and silver fir beetles in combination.

Extensive tree killing is in progress. On the most seriously affected areas practically all the Pacific silver fir is dead or dying. On large areas some trees have been killed and the green trees have been much weakened. On still other areas infestation is general, but tree killing has not yet occurred. Maps showing the degree of attack have been prepared as a basis for salvage. Some salvage is in progress.

The balsam woolly aphid is presumed to be a European insect. It has been killing grand fir in the Willamette Valley of Oregon since about 1930, perhaps earlier. A preliminary study of the gouting of infested Pacific silver fir in southern Washington showed that the insect has been present there at least 20 years, but has only recently killed trees.

A few tagged-tree plots were established in 1954 to determine the course of the epidemic. More plots are planned, along with studies of the insect.

Western Pine Beetle Studies

In 1953, over 1 million acres of damage by the western pine beetle were recorded. In 1954, only 267,970 acres of damage were detected by the survey.

Salvage logging of the heaviest centers of infestation is in progress on the Deschutes National Forest and the Yakima Indian Reservation. Elsewhere in the pine region, normal harvesting, with attention to removal of high risk trees, is steadily reducing the hazard of pine beetle epidemics.

Research on the western pine beetle in 1954 was confined to remeasurement of the series of plots dating back to 1937 on which methods of cutting are being evaluated in relation to mortality caused by the pine beetle.

Improvement of Survey Methods

During 1954, studies in this field developed and extended aerial photographic techniques for the evaluation of tree mortality caused by the Douglas-fir beetle. Eight mortality plots, established cooperatively in 1953 with Weyerhaeuser Timber Company on the Millicoma Tree Farm, were rephotographed in color at 1/6000 scale in a continuing study to evaluate the amount of mortality and the nature of errors of interpretation on the eight photo strip plots. Results of interpreting the 1953 and 1954 photography will be compared early in 1955.

Color photographs at 1/7920 scale were taken of a block of timber which included the eight strip plots to determine the practical application of the aerial photographic technique for making bark beetle surveys in the Douglas-fir type. Detailed study of these photographs is being made by Weyerhaeuser Timber Company and will be correlated with results obtained on the eight permanent photo strip plots.

A supplemental study to check accuracy of hand lens interpretation of color transparencies for estimating beetle killing and for locating beetle-killed groups of trees for salvage logging was made at two photo scales, 1/6000 and 1/7920. Although greater accuracy in estimating beetle killing was obtained with the 1/6000 scale, the 1/7920 scale provided excellent location of beetle groups. With the 1/7920 scale, a larger correction factor is needed to determine the total number of dead trees per group.

A cooperative photo experiment with the Deschutes Research Center and the Deschutes National Forest was conducted in the fall of 1954 to determine the application of aerial photography as an intensive management tool in the ponderosa pine type. Panchromatic photographs (with G filter) were taken of the Round Mountain experimental management block at a scale of 1/10,000. The photographs will be utilized by the Research Center for management studies.

The 75 permanent photo strip plots scattered throughout the Douglas-fir region were rephotographed in color for the second time. The mechanics of repeat vertical color photography of these plots was improved by using black and white strip mosaics for each plot. Direct positive prints made from color transparencies were stapled into strips. A red center line and the topographic details on each black and white mosaic enabled the pilot and photographer to relocate the plots and to rephotograph them accurately.

A spotting mirror for marking the end of photo plots in tall, dense timber, in which overhanging limbs and shadows often hide plot markers, was tried in 1954. Light reflected to the photo pilot during the actual photography identified the closing of the flight line and provided a more accurate photo course marker than other methods used to date.

The latest model of a portable, split-light table for stereo viewing of color transparencies in the field was tested and found quite satisfactory. Two 6-watt fluorescent lights and highly reflective surfaces provided ample illumination. This compact, light-weight unit can be conveniently carried through the woods and quickly assembled for field use. A description of the viewer has been prepared for publication.

Some changes in the methods of recording mortality information during aerial survey were developed in 1954. The inclusion of these methods in the aerial survey manual have delayed its issuance until early 1955.

Spruce Budworm Control

The Northwest Forest Pest Action Committee recommended a project of 162,000 acres in 1954 to control the spruce budworm in the heaviest centers of infestation. For the second consecutive year, control on the Malheur Unit had to be postponed due to lack of Federal funds. This limited the 1954 project to the La Grande Unit of 68,000 acres. Since 1949, a total of 3,220,000 acres has been treated at a cost of about $3,386,960, or about $1.05 per acre, as summarized below:

Year	Acreage treated	Cost per acre	Total cost	Average kill of budworm (Percent)
1949	266,000	$1.20	$ 320,400	97
1950	934,000	1.06	988,980	99
1951	927,000	1.06	982,620	98
1952	656,000	1.04	682,240	98
1953	369,000	.95	350,050	99
1954	68,000	.93	62,670	99
Total	3,220,000	$1.05	$3,386,960	98

The six-year program has been a cooperative undertaking by timber owners, the States of Oregon and Washington, and the Federal Government. The primary accomplishments are:

1. The epidemic has been steadily reduced from a peak of 2,276,000 acres in 1949 to 1,034,440 acres in 1954. Of the remaining total, 348,420 acres have been eliminated from all control plans.

2. General killing of trees has been prevented, except on about 10,000 acres.

3. Epidemic infestations have been eliminated from western Oregon and the eastern Oregon Cascades.

4. Less than one percent of 3,220,000 acres treated to date have had to be resprayed.

5. The recovery of defoliated trees following spraying has been remarkable and clearly proves the beneficial effects of the control program.

6. The practicability of aerial spraying to control the spruce budworm has been demonstrated and has since been undertaken in other parts of the United States and Canada.

After an inspection of the most critical units of budworm infestation by the Spruce Budworm Sub-Committee and a review of the survey findings by the entire committee, a control project of 601,000 acres on seven units in Oregon has been recommended for 1955. This project if carried out should achieve substantially complete control of the critical epidemic in the commercial timber stands west of the summit of the Wallowa Range in Oregon.

Plans for Forest Insect Research in 1955

Activities of the Division of Forest Insect Research are scheduled to continue along three main lines as heretofore: research, surveys,

and technical supervision of control. Additional personnel will make it possible to improve survey coverage and to step up research on the spruce budworm, silver fir beetles, and survey techniques. The studies on survey techniques will be jointly conducted with the Division of Economics. The following projects are planned:

Spruce Budworm Studies

1. Publish results of study of effects of aerial spraying on the principal spruce budworm parasites.

2. Prepare progress report on the study of budworm parasites, including a list of the species recorded in Oregon and Washington.

3. Continue population studies on sprayed and unsprayed areas.

4. Intensify cooperative studies of host and ecological relationships affecting budworm populations.

5. Conduct a sampling experiment designed to test foliage sampling units and to define the crown position at which estimates of average populations may be consistently obtained.

6. Lend technical assistance to educational institutions toward cooperative studies in spruce budworm research.

Douglas-fir Beetle Studies

1. Intensify ecological studies on relationships between stand conditions and outbreaks of the Douglas-fir beetle.

2. Establish regionwide permanent plots for evaluating mortality in Douglas-fir stands.

3. Continue deterioration studies of beetle-killed timber.

4. Publish data collected from mortality plots during the period 1946-54.

Silver Fir Beetle Studies

1. Train one entomologist for full-time assignment on the project.

2. Continue plot studies of the character and extent of beetle-caused damage.

3. Continue studies of the rate of deterioration of beetle-killed trees.

4. Reinventory plots to obtain additional data on the trend of the epidemic.

5. Renew studies of the biology and natural control of the beetles.

Balsam Woolly Aphid Studies

1. Summarize data obtained from study plots established in 1954.

2. Reinventory study plots and establish additional ones.

3. Make test flights at monthly intervals to determine the best time for aerial detection of damage.

4. Initiate biological studies of the insect.

Improvement of Survey Methods

1. Issue aerial survey manual.

2. Analyze and report upon completed aerial photographic studies.

3. Continue to develop equipment and improve methods for detecting and evaluating forest insect outbreaks.

4. Rephotograph and interpret aerial photo plots in the Douglas-fir region.

5. Develop and carry out joint studies with the Division of Forest Economics and the California Forest and Range Experiment Station.

Surveys

Surveys will be conducted along the same general lines as in 1954. Cooperators are again expected to do much of the field work. The following major jobs are scheduled:

1. Coordinate the regional survey program in Oregon and Washington and conduct the division's share of this project.

2. Rephotograph the 75 Douglas-fir beetle plots in the western portion of the two States to record the trend of the epidemic.

3. Continue to enlist cooperative help on all phases of the survey program.

Technical Supervision of Control

This activity depends on the approval and financing of the 1955 spruce budworm control plan. Supervision of technical

phases of aerial spraying on the control units, recommended by the Northwest Forest Pest Action Committee, has been planned.

RANGE RESEARCH

Range research in 1954 was directed almost entirely to range management studies, following transfer of the reseeding phases of our program to Agricultural Research Service. Physical facilities for the Starkey grazing management study were practically completed. The calibration studies on one block of six experimental pastures were finished and the study of rates of grazing and of deferred-rotation grazing was started.

The gopher study has been terminated, excepting publication of the final results. Greater emphasis has been placed on game range habitat improvement studies, insofar as manpower would permit. A study of elk sedge, the most important single forage species in the open forest types of eastern Oregon, was started to determine how this species responds to different intensities of herbage removal at different stages of plant development. Major attention in the range condition and trend project was directed toward site classification within forage types. The study of relationships between forage and timber production was continued and seventh year observations were made.

Technical and semi-popular publications were issued on gains made by cattle on summer range, stock ponds for livestock distribution, and forage utilization on ponderosa pine ranges. The past results of the Station's range reseeding program are in the final stages of revision and are to appear in a USDA Farmers' Bulletin. Good progress has been made on a key to browse species of eastern Oregon and Washington. Papers on grazing management of big-game range were presented at meetings of the American Society of Range Management and the Northwest Scientific Association. A paper was also given on research on big-game ranges at the 1954 annual meeting of the Western Association of State Game and Fish Commissioners.

Other activities of the range research staff included a total of 11 show-me trips on the Starkey for the purpose of acquainting people with range management research methods and results on the ground. Participating in these trips were range operators, educators, students, State and Federal personnel, and foreign visitors. A range staff man served as Forest Service representative and participated in the work of the Committee on Economics of Range Resource Development which is a part of the Western Agricultural Economics Research Council. In furtherance of this phase of research, negotiations were started with the Department of Economics, Oregon State College, to formulate a plan for joint study of range cattle economics in connection with cattle studies on the Starkey Experimental Forest and Range. The Starkey staff cooperated in the establishment of debris basins to be used in watershed studies in the experimental pastures.

Other cooperation included aid to National Forest Administration and Soil Conservation Service technicians in training personnel and in the preparation of range condition standards. Field inspections of both winter and summer big-game ranges were made in cooperation with the National Forest Administration, the Oregon Game Commission, the Washington State Department of Game, and the Fish and Wildlife Service.

Grazing Management Studies

Emphasis in grazing management research was placed on developing physical facilities on the Starkey Experimental Forest and Range. Fences and water developments were completed for the second block of six experimental pastures. Grazing capacity calibration was finished for the first block of six pastures and started on the second block of pastures. The permanent sampling system was completed and consisted of 46 one-quarter-acre cluster locations, with seven 24-square-foot plots at each location, within each pasture. In subsequent years, the study will be used to compare deferred-rotation vs. season-long systems of management and three intensities of stocking.

Cattle weight gains. Cows averaged 971 pounds and were in good condition at the beginning of the grazing season. Their average daily gain of 0.73 pound was considerably lower than the 1.8 pounds of daily gain reported on southwestern Montana summer range in 1952. The Montana cows, however, averaged only 783 pounds in June, which probably accounts for their faster rate of gain. Weights and gains of the Starkey cattle on 11 moderately grazed pastures during the 111-day season in 1953 were as follows:

Class of cattle	Weights		Gains	
	Initial	Final	Seasonal	Daily
	Pounds	Pounds	Pounds	Pounds
Cows	971	1,052	81	0.73
Steer calves	246	467	221	1.99
Heifer calves	232	442	210	1.89
All calves	239	455	216	1.95

Steer calves averaged 14 pounds heavier than heifers in June, and continued to gain at a faster rate throughout the summer. By October 1, the steers outweighed the heifers by 25 pounds. Although the variation in individual calf gains was considerable, ranging from 135 to 275 pounds, 70 percent of the calves made gains of 200 pounds or more during the summer grazing season.

Although all pastures were scheduled to receive moderate use, eight acres of usable range per animal unit month, one pasture was accidentally grazed 25 percent heavier or at the rate of six acres per AUM. Calves on the moderately grazed pastures gained 209 pounds during the 111-day grazing season as compared with 190 pounds for calves on the heavily grazed pasture. Cows under moderate grazing gained 54

pounds, or more than four times as much as the 12-pound gain for cows under heavy grazing. Utilization of bluebunch wheatgrass, the most important forage species, was 59 percent under heavy stocking and only 45 percent under moderate stocking.

These comparisons indicate that the reduction in weight gains of cows was related to the 25 percent increase in stocking. These preliminary results are interesting, since studies in other regions have not always shown immediate differences in weight gains when different stocking intensities were applied. Future results at Starkey, based upon several pastures grazed at different intensities, may reveal other factors which affect weight gains of cows and calves.

Control of livestock movements. The effectiveness of small stock ponds in obtaining better distribution of cattle and more uniform use of forage was demonstrated on the Starkey Experimental Forest and Range during the past year. Utilization of bluebunch wheatgrass, the most important forage species, was only 30 percent on one 1,000-acre area where cattle formerly concentrated because of choice forage, adequate water, and gentle topography. During the 10-year period, 1940-49, average use of bluebunch wheatgrass on this same area was 63 percent.

Past efforts to reduce livestock concentrations by riding the range, salting, and distribution of cattle at the beginning of the grazing season were largely ineffective owing to lack of stock water on adjacent higher elevation range. Utilization of forage adjacent to natural or developed water was severe. Large areas remote from stock water received little or no grazing use. This undesirable pattern has been changed by construction of small stock ponds by bulldozers at an average cost of $17 per pond.

At the beginning of the grazing season, cattle were distributed on the higher elevation range where stock ponds had been constructed. Groups of 15 to 20 cattle were frequently observed watering and grazing near the new stock ponds. When the usual pronounced drift of cattle to lower range in mid-July failed to materialize, the range rider was forced to move 200 head to the lower range. The improved distribution, following construction of a few ponds, resulted in more uniform use of all the forage on the range. Additional details of this study have been published in an illustrated article, "Small Stock Ponds--A Practical Aid for Range Livestock Distribution," Oregon Cattleman, July 1954.

Fluctuations in forage utilization. A 10-year study of forage utilization on the Starkey Experimental Forest and Range has shown wide variations in use of the principal grass species by cattle from year to year. The study shows that forage utilization during any one year is an unreliable basis for adjusting livestock numbers. An average of utilization over several years, together with information on herbage production and management practices, provides better information for evaluating stocking rates.

Cattle numbers would have been increased after five years and decreased after four years if annual utilization had been used to adjust the stocking rate. Only in one year would a range inspector have been satisfied with the level of stocking. Since cattle utilize grasslands more closely than timbered range, it is evident that summer ranges in eastern Oregon should be stocked at a level which will insure sustained production of the important grassland species. If the stocking rate on the Starkey had been at a level to obtain 50 percent use of bluebunch wheatgrass on timbered range, the utilization on the grassland would probably have equaled or exceeded this amount in all years except 1947 and 1948, and would have exceeded 70 percent in the drought years. Additional details of this study are contained in an article, "Fluctuations in Forage Utilization on Ponderosa Pine Ranges in Eastern Oregon," Journal of Range Management, November 1954.

Range Condition and Trend

Tentative classifications and descriptions of range condition were developed for one meadow site, three bunchgrass sites, and two subalpine grassland sites. Species lists for these sites are subject to further revision. The list shown below, as an example, includes some of the more common plants found on bunchgrass range (sites III and IV, slopes of 5 percent or more):

Most desirable	Intermediate	Least desirable
Agropyron spicatum	Bromus carinatus	Achillea lanulosa
Balsamorhiza sagittata	Crepis acuminata	All annuals
Festuca idahoensis	Geranium viscosissimum	Antennaria spp.
Hieracium scouleri	Helianthella uniflora	Artemisia spp.
Koeleria cristata	Lupinus spp.	Aster spp.
Purshia tridentata	Penstemon spp.	Chrysothamnus spp.
Arnica sororia	Sidalcea spp.	Grindelia spp.

The different sites are separated on the basis of soil characteristics, moisture relations, slope, and variations in proportions of grasses and other species present. On this basis, for example, it appears that two site classes can be recognized for the green fescue (Festuca viridula) subalpine type. Pickford and Reid (USDA Circular No. 655) listed lupine as being present in all condition classes, yet there are green fescue ranges in the Wallowa Mountains which are characterized primarily by green fescue and subalpine needlegrass (Stipa columbiana). These areas are found on ridges and high slopes which are subject to lighter snow pack and less drainage from higher terrain than the green fescue-lupine communities in the lower basins.

An example of species compositions for green fescue sites, as determined from Pickford and Reid's data and from recent trend cluster work, is as follows:

Species	Site I (Basin site; lupine present) (Percent)	Site II (Ridge or high slope site; lupine absent) (Percent)
Festuca viridula and other species	68	82
Stipa columbiana and other species	0	18
Lupinus spp.	32	0
Total	100	100

Fire Control of Undesirable Plants

Prescribed burning of overstocked stands of ponderosa pine reproduction on the Colville Indian Reservation showed a reduction in density of shrubs, the chief losers being pinemat manzanita (Arctostaphylos nevadensis) and snowbush ceanothus (Ceanothus velutinus), the latter being a species of value to big-game animals. Densities or coverages before and after burning are shown in the following table:

Class of vegetation	Before burning (Percent density)	First season after burning (Percent density)	Relative change (Percent)
Grasses	3.40	4.37	+ 29
Broad-leaved herbs	1.34	5.26	+ 293
Shrubs	10.02	5.84	- 42
Total	14.76	15.47	+ 5

In the first growing season after the controlled burn, gains in coverage of some herbaceous species exceeded losses of others. The major portion of the gain was made by weeds of low to moderate palatability to sheep, i.e., Lupinus spp. and gland cinquefoil (Potentilla glandulosa). Although the small amounts of bearded bluebunch wheatgrass (Agropyron spicatum) and Idaho fescue (Festuca idahoensis) originally present were reduced by the burn, pinegrass (Calamagrostis rubescens) grew so rapidly that a 29 percent increase was recorded for grasses as a whole.

The effects of prescribed burning on forage species may be short-lived. The first year shifts were of moderate consequence in aiding or interfering with the forage supply for domestic livestock. Of greater interest to the livestock operator will be the change in number of live trees one foot or taller that originally occupied the sample plots. The fire reduced their number by 68 percent. Thinning of overstocked stands is desirable silviculturally. It may also be desirable from the range management viewpoint since thinning increases both the amount and accessibility of forage.

Big-Game Ranges

The purpose of this phase of research is to develop and test methods of improving big-game range habitat and to determine the nature of competition or compatability between big game and livestock on eastern Oregon and eastern Washington ranges.

Game forage seeding for elk on Bald Mountain, Snoqualmie National Forest, showed the benefit of sawdust plus nitrogen on intermediate wheatgrass. Six methods of cultural and seeding treatment and four levels of fertilization or soil amending were used:

Cultural and seeding treatment	Fertilizer and soil amending treatments
Disk and drill	1 inch sawdust (16.8 tons/acre) with 400 lb. N/acre
Disk, drill, and cultipack	2 inches sawdust (33.6 tons/acre) with 800 lb. N/acre
Disk, cultipack, and drill	40 lb. N per acre
Disk, and broadcast seed	60 lb. N per acre
Disk, broadcast, and harrow	Control
Disk, broadcast, and cultipack	

Germination and emergence did not occur until early June. The seedling stands were only 2 to 6 inches tall by the first week in August, and 3 to 8 inches tall by September 1. Perhaps this should be considered good growth at the altitude and latitude of the study area. At the August observation, only grass seedlings on the sawdust treated plots showed good vigor and vegetative development. Where two inches of sawdust plus two applications of nitrogen had been employed, an average of 2.0 seedlings per square foot was found. One inch of sawdust plus nitrogen produced 1.4 seedlings per square foot. Respective controls for these trials showed 1.1 and 0.7 seedlings per square foot. Among cultural treatments, cultipacking after drilling appeared to be detrimental--only 0.5 seedling per square foot was found.

Adaptability trials of game forage species on the Chelan National Forest showed good to excellent stands of Agropyron intermedium, Bromus erectus, and Poa ampla. Agropyron subsecundum was a failure and Festuca ovina (P-272) was a near failure. Nomad and Ladak alfalfa were outstanding for the site, with at least 11 young plants per square foot and good vigor ratings.

Bitterbrush plantings on winter deer range in Grant County, Oreg., were almost complete failures. Differences in grass stands on three different sites in this study were obscured by severe cattle grazing. Cheatgrass competition within fenced plots was severe. Of the seeded grasses, Agropyron intermedium showed the best vigor.

Competition for forage between big game and cattle was computed from pellet counts for both deer and elk on permanent plots established

in 12 experimental pastures of the Starkey Experimental Forest and Range. The use of these pastures by game averaged 19 percent, half of which was by deer and half by elk. Use in individual pastures varied from 11 to 33 percent. Most of the elk use occurred during spring and fall months. No elk were observed in the area during the summer. Deer use was distributed throughout all seasons.

These observations are demonstrating the importance of understanding and knowing the impact that game animals have on the range. A 33 percent use by game on a pasture moderately stocked with cattle can result in destructive use of the vegetation. Even though game animal numbers may vary from area to area, or from year to year, they must be considered as one of the major factors in range management.

Timber-Grazing Relationships

A summary of the logging study, with reports on one Oregon and one Washington transect in their seventh years after logging, is now available. Since all transects in the study have not had their seventh measurement, the results of the study are still preliminary. Information on the first year effects has been published in farm magazines and in the Journal of Forestry. These publications reported that forage cover was at least temporarily destroyed or covered by slash on an average of one-fourth of the ground surface. More than one-half of this disturbance was severe enough to destroy root crowns of desirable perennial grasses.

In the seventh season after logging, one transect in Oregon and one in Washington were measured. Rates of recovery differed on the two transects as shown in the following table:

Coverage in Percent of Understory Vegetation on Two Transects Before and After Logging

Class of vegetation	Before logging	After logging			
		1st yr.	2d yr.	4th yr.	7th yr.
	Percent	Percent			
Washington Transect (Lost Creek)					
Grasses (other than cheatgrass)	12.90	6.03	3.93	5.53	9.79
Cheatgrass	--	0.07	0.23	1.48	2.20
Broad-leaved herbs	6.75	3.13	3.24	6.84	3.58
Shrubs	2.25	2.22	0.91	1.73	2.83
Total	21.90	11.45	8.31	15.58	18.40
Oregon Transect (Malheur No. 2)					
Grasses	3.32	1.36	2.26	2.45	2.87
Broad-leaved herbs	2.45	2.02	3.94	4.72	4.88
Shrubs	0.75	0.38	0.61	0.69	0.65
Total	6.52	3.76	6.81	7.86	8.40

Improvement on the Washington transect was slowest, plant cover being 16 percent under prelogging density, whereas the understory cover of the Oregon transect was 29 percent above prelogging density. Invasion of the highly inflammable cheatgrass into logging disturbed areas occurred in the Washington study, constituting 12 percent of the understory cover. The Oregon transect at the last observation continued its early established trend toward a predominantly weedy cover. Two points of similarity exist between the transects in the two States: (1) Good gains have been made in the overall quantitative restoration of understory cover; and (2) the quality of the restored cover is still inferior to what it was before logging.

The transect averages reported above include various degrees of logging disturbance and do not indicate the results of total denudation. On five samples within the Washington transect, seventh season data were obtained from areas which received major skid disturbance. Recovery on these plots lagged far behind the trend of the general transect condition. Ignoring the transitory contribution of cheatgrass to the understory, cover was only 60 percent of the prelogging amount.

Ecology of Elk Sedge

With more use being made of the open forest type on the Starkey Range by application of better management practices, more information was needed on effects of herbage removal from elk sedge in different amounts and at different seasons. Three intensities of removal are being tested. The 20 percent level corresponds to the degree of use received on most summer ranges where management practices have not been designed to obtain more efficient use of the timber types. The 40 percent removal lies within the range of average use received by elk sedge on the Starkey where management practices have achieved efficient use of the timber types. The 60 percent removal corresponds to the heaviest use usually recorded for individual plants around timber fringes or under a heavy intensity of use.

Sixty percent herbage removal, by weight, reduced the vigor of elk sedge after one year of treatment. Numbers and heights of seed stalks were reduced. Under moderate intensity of harvest, 1.5 times as many seed stalks were produced as under heavy removal of herbage. The light intensity of harvest resulted in production of 1.4 times as many seed stalks as were produced under heavy harvest. Seed stalks were an inch longer under light and moderate intensities of herbage removal than under the heavy intensity. Seed-stalk production was reduced under all intensities of harvest as a result of harvesting elk sedge in the late dough stage of seed development.

Elk sedge harvested to ground level at the late dough stage was nearly eliminated from the stand. All above-ground material was removed from two plots of elk sedge in 1953 at two different phenological stages, one at the initial formation of seeds, the other during the dough stage. The plants harvested earliest regrew five inches.

Plants harvested later regrew only two inches. In 1954, the plants harvested the year before at the earliest stage produced a good volume of forage, numerous seed stalks, and appeared to be as vigorous as other plants in the area. The plants harvested the year before at the later stage produced very little herbage, no seed stalks, and showed indications of low vigor.

Range Management Techniques

Some modifications of the point analyzer method for measuring ground cover on small circular plots were made during 1954. A method was needed which would be more accurate than square-foot density estimates, have greater mobility, and be less time-consuming than the modification developed by Paul E. Packer in the Intermountain Region. Tests made in 1953, using modification showed that 40 mechanically spaced point observations per plot on a transect of four plots, a total of 160 point observations, provided a reliable measure of organic matter (live vegetation and litter), bare soil, and rock. The average time required for 160 point observations, 32 minutes, was prohibitive for extensive inventory work.

One modification developed during the past year was the replacement of the bulky point analyzer frame with a diameter rod. The rod is notched at 20 evenly spaced points at which observations are made. The rod is supported over the plot at any desired height by chaining pins placed at the edge of the plot. For 40 observations per plot the rod is placed over the plot parallel to the line of plots in the transect, and again at right angles to this line.

Another modification was replacement of the point with the loop used in the three-step method developed by Kenneth W. Parker. Tests showed little difference between measurements of organic matter, bare area, and rock with use of either the point or loop methods. The loop modification was selected since it is better adapted for use with the diameter rod, and is less time-consuming than the point observation method.

This modified method was used on an inventory of ground cover on grassland range in six experimental pastures. Observations were made on 108 transects, each consisting of four plots. The average time required per transect, 160 loop observations, was 20 minutes, as compared with 32 minutes when the bulky point analyzer frame and point method was used. The modified method provides a simple and accurate measure of ground cover at a cost which is only slightly greater than estimates by the square-foot density method.

Some changes in the line transect system resulted in greater speed without loss of essential information. Instead of recording a separate symbol for each observation a tally was made against a list of species and other items regularly observed in the vegetation type. The summarization process was simplified as a result of this change. Time required for recording and summarizing was reduced 50 percent.

Plans for Range Research in 1955

Consideration will be given to the study of range economics, particularly those aspects that are outside the scope of our present management study. Two problems which could be worked on at Starkey, if suitable cooperation could be found, are: (1) Economics of marketing calves, long yearlings, or long two-year-old steers from summer ranges; (2) economics of trailing vs. trucking cattle to and from summer ranges.

Publications planned for completion include the USDA Farmers' Bulletin on reseeding summer ranges, the "Key to Important Woody Plants of Eastern Oregon and Eastern Washington"; a magazine article on integration of range management and animal husbandry in college curricula; and an article on condition and trend criteria. An article on "The Need for Research on Ranges Used by Big-Game" is scheduled for publication in the "Proceedings of the Western Association of State Game and Fish Commissioners." The article, "Relation of the Dalles Pocket Gopher to Establishment and Maintenance of Range Grass Plantings" is scheduled for early submission to the Journal of Range Management.

On the Starkey, one block of pastures will be grazed under light, moderate, and heavy grazing intensities and under deferred-rotation and season-long systems of management. Calibration will be completed on the second block of pastures. Inventories of herbage production and utilization will be continued. The "Guidebook to the Starkey Experimental Forest and Range" will be completed and processed for publication.

Condition and trend studies will be expanded by starting a study of green fescue range in the Cascade Range of Washington. Further revision of standards will be made for bunchgrass, meadow, and subalpine ranges.

A field examination will be made to determine desirability of continuing forage observations after 1957 on the prescribed burning study. Timber observations are to be continued until 1967.

Studies of utilization standards and utilization of browse species on game pastures will be started on the Starkey. Field review of big-game management problems and field work on methods of improving big-game range will be continued.

Studies of effect of logging on permanent transects will be done according to study plan. Range research personnel will participate in establishment of a grass-tree seedling competition experiment on the Ochoco National Forest.

A Station research note will be prepared to summarize the intermediate results of herbage removal on production of elk sedge.

WATERSHED MANAGEMENT RESEARCH

In 1954, we continued our effort to expand watershed management research in the Pacific Northwest. A small study was begun this fall on the Starkey Experimental Forest and Range to relate soil erosion to intensity of cattle use. Also some progress was made toward a cooperative study of water yield and sediment production in the Green River watershed, the municipal water supply for the city of Tacoma. Possibilities for similar cooperation in Portland's city watershed were explored in preliminary discussions with city officials last summer. Through 1954, our watershed research project at the H. J. Andrews Experimental Forest was kept alive in the expectation that we will soon be able to provide much needed expansion.

How Much Erosion Results From Cattle Grazing?

We are hopeful that an answer can eventually be obtained from the Starkey Experimental Forest and Range in the Blue Mountains of Oregon. In October we began a study to determine relative quantities of eroded soil produced by grazing in six experimental cattle-management pastures. Determination of soil erosion was included as one of the several objectives when this pasture study was planned in 1948. Effects of cattle grazing at light, moderate, and heavy intensities on herbage production, forage utilization, species composition, and soil erosion will be appraised annually beginning in the summer of 1955.

A measure of soil erosion will be obtained by measuring amounts of sediment caught in an excavated basin located in each pasture. Sediment catchment basins have been constructed near the head of small natural watersheds. Areas above the basins average about 50 acres and contain a mixture of timber and open grassland. Each of the six cattle-management pastures contains one catchment basin and a seventh has been constructed in an adjoining pasture designed to study game use only.

Accumulated silt will be measured each fall after close of the grazing season. Successive yearly measurements of the depths of soil will give volumes which are contributed from the drainage area above each basin. Effect of different rates of grazing are expected to appear in these measurements, but differences will probably not be pronounced until grazing treatments have continued for several years.

A Cooperative Study Proposed for Green River, Wash.

Green River watershed, 231 square miles in area, is the source of most of the domestic supply for the city of Tacoma. The Water Department has a problem with silt pollution resulting from activities in the watershed over which they have no control. Most of the area is forested, ownership is mixed, and logging has been carried on for more than 30 years.

Since 1946, the city of Tacoma and the U. S. Geological Survey have been cooperating in the measurement of flow on the main stream and five tributary drainages. Primary objectives have been to determine the effect of logging on water yield and silt pollution. However, it has been difficult to maintain control over logging necessary for accurate long-time runoff. The relatively large size of the drainages, the mixed ownerships, and the absence of a logging plan designed to fit the experimental needs have largely nullified efforts to obtain significant results in evaluating water yield. The only measurements of silt have been obtained at the intake works. No attempt has been made to relate the amount of turbidity to source areas or causes.

During the past summer the Experiment Station, the Snoqualmie National Forest, the district office of the Geological Survey, and Tacoma Water Department explored the possibility for further investigations in the watershed. Two reconnaissance trips were made in an effort to locate a set of paired watersheds in which the effect of timber cutting on water yield could be studied. A second objective was to find a suitable location to study relative amounts of silt disturbance resulting from tractor and high-lead logging.

Two drainages which appear suitable for water yield studies have been located in an area of old-growth Douglas-fir. This winter, some preliminary plans are being made for a joint study in these areas.

Watershed Studies Continue at H. J. Andrews Experimental Forest

Runoff records were maintained throughout 1954 in three small experimental watersheds in which the effect of logging on streamflow will be evaluated at some future time. At present, these drainages have a complete and undisturbed cover of old-growth Douglas-fir. Before launching into the logging treatment phase of the experiment, it is necessary to establish a standard of streamflow performance for "natural" or pretreatment watershed conditions. In 1954 another year was added to the number needed for the development of this standard.

Pumice Soil is One of Nature's Best Water Regulators

Runoff records recently analyzed by the Station show how soil formations can result in widely different characteristics in the behavior of streams. For example, pumice of the high Cascade Range is remarkably efficient in regulating streamflow. In southwest Oregon the greatest measured flow of the North Umpqua River and tributaries on the pumice formation is only 5 or 6 times the least flow. Likewise, tributaries of the Rogue River show ranges between low and high flows which rarely exceed a ratio of 1:50. By contrast, maximum flows exceed the minimum by 1,000 times or more in streams like the South Umpqua River which drain from relatively dense soils.

The north and south forks of the Umpqua River are approximately equal in drainage area and annually yield about the same amount of water.

However, the North Umpqua, with about 30 percent of its drainage covered with pumice, has a well-sustained flow while that of the South Umpqua is quite variable.

A knowledge of the physical characteristics and location of various soils in a watershed greatly aids in the intelligent application of flood-control measures. Soil formations found in the South Umpqua River watershed lead to winter flood-producing conditions in the entire drainage. During the flood of December 1950, the forested areas of this drainage yielded flows at the rate of 82 cubic feet per second per square mile (csm). In the North Umpqua drainage, forested areas on pumice soil yielded only 4 to 8 csm.

Plans for Watershed Management Research in 1955

Prospects for an expanded program of watershed management research in 1955 appear to be bright. In view of this, a high-priority activity in the coming year will be in the category of planning to determine the scope, objectives, and location of new research. Specific activities will be:

1. Develop a complete plan of watershed management research for the Pacific Northwest.

2. Maintain records from the study watersheds at the H. J. Andrews Experimental Forest and the sediment basins at Starkey Experimental Forest and Range.

3. Continue to develop the groundwork for cooperative watershed management research with interested agencies, private concerns, and municipalities.

FOREST UTILIZATION RESEARCH

Utilization of logs used in primary manufacturing plants was higher in the Pacific Northwest this year. Slabs, edgings, veneer clippings, and other residues formerly disposed of in waste burners made up a substantial volume of the raw material of pulp mills, hardboard, and softboard plants. At present over one-fourth of the raw material used in pulp mills in Oregon and Washington comes from sawmill and plywood residue. The hardboard industry, consisting of nine plants in the region with a rated capacity of 440 million square feet per year, depends entirely on the same sources for raw material. In other words, the pulp and hardboard industries are now using the equivalent of 1.3 million cords of wood that otherwise would have little commercial value.

Several sulfate pulp mills, which can utilize Douglas-fir, are now getting a major portion of their raw material supply in the form of chips produced at sawmills and plywood plants. One large company has

constructed a pulp mill without the usual wood preparation room and depends entirely on chips from outside sources. Recently plans were announced by two other companies to build similar plants.

Another industry now starting in the Pacific Northwest, which will utilize mill byproducts, is coreboard manufacture. One such plant began operating during 1954. Three more plants are under construction and two are in the planning stage. Coreboard manufacture consists essentially of gluing small particles of wood together in large sheets, although several process variations are used. Coreboard is used mainly by the furniture industry for core stock. It is planned that much of this product will be smooth-surfaced or will be sanded so that high-grade furniture veneer can be applied without crossbanding.

Undoubtedly, the number of plants that can utilize mill residue as the principal raw material will continue to increase. Although good progress has been made, the region still has a large unused supply of this material.

The Division of Forest Utilization Research continued to operate as a liaison between the U. S. Forest Products Laboratory at Madison, Wis., and the wood-using industry in this region. Research in wood utilization under way at State and private organizations and industry problems were reviewed and coordinated with programs of the Forest Products Laboratory.

Those utilization problems receiving major consideration during 1954 are summarized below:

Lumber Grade Recovery Studies

Under the stimulus of the division a committee was organized early in the year to promote grade recovery studies in the ponderosa pine region. A group was formed consisting of representatives of the Western Pine Association, Bureau of Land Management, Bureau of Indian Affairs, Oregon Forest Products Laboratory, and both the administrative and research branches of the Forest Service. All agreed to cooperate on the project and the Oregon Forest Products Laboratory accepted responsibility for the computation and report writing for studies made in Oregon.

Priority was given to the associated species of the pine region with later work to be done on ponderosa pine. From previous studies some information was being used for ponderosa pine but no lumber recovery data were available for the associated species.

The first study was made at Tygh Valley Lumber Company at Tygh Valley, Oreg. Two hundred and sixteen Douglas-fir logs and 72 white fir logs were scaled, graded, and diagrammed. The second study was made at the Mt. Emily Lumber Company at Enterprise, Oreg., where data were obtained on 127 Douglas-fir, 99 white fir, and 177 larch logs.

Green chain lumber grade and footage tallies were obtained by individual logs at both mills. Part of this lumber was followed through the dry kilns and planers and again regraded in order to determine the final shipping tally grades.

Data from these studies were used to establish a set of log rules that will be a more reliable basis for establishing log and timber values than existing methods. Considerable additional work is planned on this project and more data are needed to determine a basis for appraising other species and to establish quality differentials throughout the region.

Another lumber recovery study, aimed at developing data to appraise more accurately Douglas-fir and western larch on the Chelan National Forest, was supervised by this Station at the joint request of the Forest Supervisor and Biles-Coleman Lumber Company, at Omak, Wash. A special crew operated the mill for one day, cutting 446 Douglas-fir logs (scaling 58 thousand board feet) and 200 larch logs (scaling approximately 20 thousand board feet). All logs were scaled and graded and green chain lumber recovery data were obtained by species. The lumber was kiln dried, surfaced, and again graded, making it possible to determine the amount of fall-down between green chain and shipping tally. The Western Pine Association furnished a log grader and a lumber grader for the project and the rest of the crew was provided by the Forest Service and the company.

The division assisted the Division of Forest Management Research in making a lumber grade recovery study of second-growth Douglas-fir logs from the Wind River Experimental Forest. The overall study consisted of following logs from a thinning study in a 100-year-old Douglas-fir stand through the logging and milling operation. Individual logging costs had previously been obtained and information on the amount of overrun and lumber grades that could be expected from this type of timber was desired. Lumber recovery data were obtained on 160 individual logs which were cut at the Hegewald Lumber Company's round-log gang mill at Stevenson, Wash.

Red Alder

Early promotional work by this Station and the Madison Laboratory on using red alder is beginning to produce results. Several large pulp companies are commencing to utilize this species. Two are making substantial additions to their plants so that they can use large quantities of alder. Specially designed log barkers have been installed. The alder pulp will be blended with pulps made from Douglas-fir and other species. Alder pulp is a short-fiber material and when used as a filler will improve the quality, especially of Douglas-fir pulp, which has the coarsest fiber of any western softwood.

The red alder log and lumber grading study initiated by this Station was completed this year and a report, "Red alder log and lumber grading," by J. R. Pfeiffer of the Oregon Forest Products Laboratory and A. C. Wollen of the Madison Laboratory was released in October by Oregon

Forest Products Laboratory. The report concluded that the hardwood log grading rules proposed by the Madison Laboratory and accepted as Forest Service standard are suitable for red alder log grading with only minor modification. Also, the lumber grading rules used by the National Hardwood Lumber Association were found applicable to lumber from this species. Lumber grade recovery from red alder logs compares favorably to that from many eastern hardwoods. Cooperators in the study were the Madison Laboratory, the Pacific Northwest Forest and Range Experiment Station, and the Oregon Forest Products Laboratory. The region has a few well-equipped hardwood mills that are now turning out well-manufactured products and some of the larger softwood lumber companies are planning to cut alder and other hardwoods.

Wyssen Skyline Crane

The first of the large-size Wyssen skyline cranes in the United States was installed on the Chelan National Forest in October. Mr. Wyssen and a 4-man crew from Switzerland began operations on a 7.2 million-board-foot experimental sale on the Chelan National Forest.

Station personnel had a major part in acquainting Wyssen with Northwest conditions and in arranging for the initial experimental operation. This system for logging rough topography is expected to utilize an additional log source rather than replace existing operations.

Wyssen's operation is located in the Jack Creek drainage, 10 miles east of Twisp, Wash. The experimental area consists of a thousand-acre tract considered inoperable for tractor logging. In addition to having rough topography, it contains some light pumice soil that would erode badly if disturbed by tractor.

Machinery consists of a 55 hp. air-cooled diesel motor, a 1-inch skyline, a $\frac{1}{2}$-inch operating cable, a patented carriage, and a special telephone system which keeps machine operator, choker setters, and the man on the landing in communication. All equipment was manufactured in Switzerland.

The model in use on the Chelan is adequate for most east side logging but not large enough for the old-growth Douglas-fir west of the Cascades. However, the Wyssen Company is now constructing a larger machine, called the "10-ton," which may be ready for trial in the Douglas-fir region next summer.

The Wyssen skyline crane has possibilities for logging on rough topography, on rocky areas where road costs are excessive, and on areas with unstable soil that would erode badly if logged by usual logging methods. Logging cost data will be collected and soil disturbance measured on the experimental sales where the Wyssen system is employed.

Kiln Drying Lumber

The division cooperated with the Oregon Forest Products Laboratory in conducting the sixth annual week-long course in lumber seasoning at Corvallis. While intended primarily for the dry kiln operator, the subject matter given covers the properties and performance of wood sufficiently to apply both to manufacture and sale of lumber products. Consequently, attendance at the course includes mill foremen, superintendents, and managers as well as representatives from sales departments. The short course at Corvallis is currently the only one of its kind given in the United States west of the Rocky Mountains. Thirty-one men attended this year, coming from Washington, Idaho, Montana, California, and New Mexico, in addition to Oregon. The U. S. Forest Service cooperated by furnishing one instructor from the Forest Products Laboratory at Madison and one from this Station.

A report, "Seasoning and machining degrade in young-growth Douglas-fir dimension lumber," was published in May 1954 by the Oregon Forest Products Laboratory, with A. C. Knauss of this division as coauthor. It covers kiln drying studies made in 1953 jointly by the Oregon Forest Products Laboratory and the Forest Service. Current commercial practice dries common grades of lumber to around 18 percent moisture content. Past experience with large-knotted old growth has given excessive degrade if dried further. However, this study showed that lumber from young growth could be dried to 12 percent and then surfaced without serious degrade. Advantages of drying to this lower moisture percent is an additional reduction of shipping weight by 100 pounds per thousand feet of lumber and reduction by 1.6 percent of the amount of shrinkage that can be expected after the lumber is put in use.

Cooperation has continued with the several dry kiln clubs in the region. These meetings serve as contacts through which technical information developed by research can be relayed directly to industry. The results of research in industry are also disseminated at these meetings. An example was a report by Virgil Davis, Booth-Kelly Lumber Company, Springfield, Oreg., entitled "Steam consumption in the kiln drying of western softwoods," presented at kiln club meetings and also at the national meeting of the Forest Products Research Society. His study showed that a modern battery of dry kilns used 2.57 pounds of steam for each pound of water evaporated from lumber when drying a mixture of old-growth Douglas-fir and western hemlock.

Cost of supplying steam for operating dry kilns, sawmills, and remanufacturing plants is becoming increasingly important as utilization of wood fiber improves in sawmills and plywood plants. The rapid expansion in the use of mill residue for chips for pulp has reduced the available wood fuel supply. Interest, therefore, is growing in developing better insulated dry kiln construction to reduce the steam requirements for drying lumber.

Laminating

USDA Technical Bulletin 1069, "Fabrication and Design of Glued Laminated Wood Structural Members," based on extensive research work at the Madison Laboratory on the properties and use of wood adhesives and on the fabrication of strong and durable glue joints in wood members, was issued this year. The work was specifically aimed at laminating of white oak boat framing parts for naval ships and at Douglas-fir structural arches, beams, and trusses for both interior and exterior use. Douglas-fir is the principal species of lumber used in this country for glued laminated wood framing members and many of the major producers are located in this region. During the past few years these laminators, as well as boat builders, have also fabricated glued laminated white oak keels and frames for naval minesweepers.

A notable improvement in the softwood laminating industry this year has been the use of drier lumber. The industry generally has adopted a practice of drying Douglas-fir lumber to about 12 percent before surfacing and gluing. The moisture content of the laminated member thus is near the level it will reach in service. This minimizes further drying of the relatively large members, which would otherwise be accompanied by objectionable shrinkage, surface checking, and open glue joints.

The Forest Service is using glued laminated Douglas-fir stringers and other structural members in building wood bridges in its national forest road system. First installation in this region was made early in 1953. Now 40 such bridges have been built. Laminated members as large as 11 inches by 44 inches in cross section and up to 85 feet in length have been used in this construction. Bridges are designed to carry the normal load permitted on State highways and in some cases to accommodate heavier loads carried by large logging trucks operating off State roads. All laminated members have been preservatively treated with creosote for protection against decay. A useful life of at least 50 years is expected of the wood bridges. About half of the bridges currently being built by the Forest Service in this region are of wood glued laminated members.

Deterioration of Hemlock Logs in Cold Decks

A study is under way at Oregon Pulp & Paper Co. at Salem, Oreg., to measure the amount of decay which will develop in hemlock logs stored in cold deck for one year and for two years. In this study one deck is heavily sprinkled with water to keep the logs thoroughly wet throughout the entire dry summer season. Another deck is maintained in the conventional dry condition. Half of the logs in each deck will be cut up and examined in 1955 and the remainder in 1956. Divisions of Forest Disease Research and Forest Utilization Research are making the study.

Strength Properties of Softwood Lumber

Designing engineers and architects are asking if structural lumber cut from young, fast-grown Douglas-fir timber will provide sufficient strength to meet the required design stresses. Old-growth Douglas-fir has for years been a preferred source of structural wood. In recent years there has been a rapid increase in harvesting second-growth stands and it is important to know the strength properties of second-growth material. Tests at the Madison Laboratory have shown that young-growth Douglas-fir furnishes the required working strength unless the ring count fails to meet the current grade specifications. Where the ring count is not adequate, sufficient strength is furnished, however, when the summerwood comprises at least one-third of the annual ring thickness. Strength of lumber cut from second-growth Douglas-fir is important to the laminating industry, which, in many cases, prefers this type of material for gluing.

ASTM Wood Pole Research Program

For the past few years a committee of the American Society for Testing Materials has been planning a program of pole testing to settle some of the unsolved problems relating to the strength of treated and untreated poles of various species. During the year actual testing work got under way with funds contributed by pole users and producers. Cost of the project has been estimated at 160 thousand dollars, which will cover full-scale testing of green and treated Douglas-fir, southern pine, lodgepole pine, redcedar, and western larch poles. All testing will be the responsibility of the Madison Laboratory. This Station assisted in the collection and shipment of green Douglas-fir poles. Treated poles of this species will be obtained at a later date and shipped to Madison.

Machining Douglas-fir Door Stock

A serious problem in machining of Douglas-fir door stock is the slivering or loosening of the annual rings when surfacing edges of vertical grain stiles and rails. Last year the Madison Laboratory studied the structure of Douglas-fir lumber suffering from this condition and no difference in wood structure between various specimens of Douglas-fir could be found to explain the weakness in some Douglas-fir.

Now drying and machining studies are being undertaken at Madison to further explore this problem. This division collected Douglas-fir lumber for the study and forwarded it to Madison. Lumber was obtained from a number of areas ranging from Eugene, Oreg., to Vancouver Island, B. C.

Plans for Forest Utilization Research in 1955

Work of the division for the coming year will be much as in the past. Working relations will be maintained between industry, the Forest

Products Laboratory at Madison, Wis., and other institutions doing research in wood utilization. Major emphasis will be given the following projects:

1. Lumber grade recovery studies for all species in the ponderosa pine region.

2. Improvements in methods and equipment for logging and primary manufacture.

3. Degrade developing in kiln drying and surfacing lumber species in the pine type in conjunction with lumber recovery studies.

4. Kiln drying lumber, particularly that produced in second-growth stands in the Douglas-fir region.

5. Utilization of mill residue for the production of pulp, hardboard, and coreboard.

6. Utilization of western hardwoods for pulp, lumber, and other products.

7. Laminating and uses for laminated products.

8. Effects of growth conditions on wood quality and the relation of wood structure to its properties.

9. Utilization of white pocket Douglas-fir and other low-quality wood in paper-faced veneer and similar products.

PUBLICATIONS

Outside Publications

Baudendistel, M. E. Northwest holds key to timber survey. Western Conservation Jour. 11 (4): 28-29, 56, 58. July-Aug. 1954.

Brief summary of forest resources in Northwest and type of information being compiled under various tasks of TRR.

Berntsen, C. M. Report on tested methods of commercial thinning on steep ground. Timberman 55 (8): 94-97. June 1954.

Shows practicality of thinning dense timber on steep ground below existing roads, and that the thinning can be done at reasonable cost.

Carmean, W. H. Site quality for Douglas-fir in southwestern Washington and its relationship to precipitation, elevation, and physical soil properties. Soil Science Soc. of Amer. Proc. 18 (3): 330-334. July 1954.

Results indicate the productive capacity of forest land in terms of permanent mappable features of the forest environment.

Childs, T. W. Review of "Conk Rot of Old-growth Douglas-fir in Western Oregon," by John S. Boyce and J. W. Bruce Wagg. Jour. Forestry 52 (1): 43. Jan. 1954.

Summarizes the results reported by these authors, and points out the importance of their findings in Douglas-fir management.

Coulter, W. K. Silver fir beetles. Northwest Forest Pest Leaflet No. 1. Jan. 1954. (Processed by Industrial Forestry Association for Northwest Forest Pest Action Committee.)

A brief account of the present infestation, species of beetles involved, the damage being caused and the surveys being made to evaluate and follow the course of epidemic.

Cowlin, R. W. The forest survey. Western Forestry and Conservation Assoc. Proc. 44: 38-39, Dec. 9-11, 1953. 1954.

Brief review of the current Forest Survey reinventory program; explains some of the reasons for apparent wide differences in results of past and present inventories.

Cowlin, R. W. Forest survey improves; review will be reliable. Pulp & Paper 28 (5): 102, 106, 108. May 1954.

Describes the type of timber inventory and growth information to be presented in the Timber Resource Review; also explains some of the reasons why there are differences between past and present inventories.

Cramer, O. P. A critical look at cloud seeding. Jour. Forestry 52 (7): 515-517. July 1954.

Limitations of methods commonly used for determining effectiveness of cloud seeding projects are discussed. A more reliable procedure is suggested in which seeded storm rainfall is segregated by type of storm and comparison is made with the normal for each type.

Cramer, O. P. Recognizing weather conditions that affect forest fire behavior. Fire Control Notes 15 (2): 1-6. April 1954. Also published in National Fire Protection Assoc. Quarterly 48 (2): 136-142. Oct. 1954. With title "Weather and forest fire behavior."

Phenomena of stable and unstable air are discussed in terms of effect on fires, physical structure, and visible characteristics. Inversion, turbulence, gustiness, convection, whirlwinds, thundersqualls and fire storm are described.

Dahms, W. G. Growth of pruned ponderosa pine. Jour. Forestry 52 (6): 444-445. June 1954.

As much as one-third of the live crown length of ponderosa pine may be pruned without serious effect. More severe pruning may result in reduction in height and diameter growth.

Dunford, E. G. Surface runoff and erosion from pine grasslands of the Colorado Front Range. Jour. Forestry 52 (11): 923-927. Nov. 1954.

Describes effects of (1) moderate and heavy grazing on a bunchgrass range and (2) removal of needle litter and crown canopy in a young stand of ponderosa pine.

Eversole, K. R. Using the climbing rope and saddle in forestry. Jour. Forestry 52 (4): 285-286. April 1954.

Illustrates rigging and its use in facilitating tree climbing for pruning and cone picking.

Harris, R. W. Fluctuations in forage utilization on ponderosa pine ranges in eastern Oregon. Jour. Range Management 7 (6): 250-255. Nov. 1954.

Discusses fluctuations in forage utilization over a 10-year period and concludes that annual forage use is an unreliable basis for making adjustments in stocking numbers.

Harris, R. W. Small stock ponds -- a practical aid for range livestock distribution. Oregon Cattleman 3 (3): 7, 20. July 1954.

Tells how to locate and construct small water developments to secure more efficient utilization of range forage.

Harris, R. W. & Driscoll, R. S. Gains made by cattle on summer range. Oregon Cattleman 3 (5): 5, 24. Sept. 1954.

Summarizes summer weight gains of cows and calves on ponderosa pine - grass range on the Starkey Experimental Forest and Range in eastern Oregon.

Isaac, L. A. European forest practices of interest to American foresters. Wash., D. C., U. S. Forest Serv. 13 pp. 1954. Processed.

Includes observations on European methods in species improvement, nursery and planting techniques and cutting practices.

Isaac, L. A. Western Europe welcomes invasion of Douglasfir. Amer. Forests 60 (10): 22-23, 52-54. Oct. 1954.

American tree species, with Douglas-fir leading, are helping European foresters produce maximum yields of wood per acre.

James, G. A. & Hayes, G. L. Highlights of a Port-Orford-cedar regeneration study. Jour. Forestry 52 (11): 852-855. Nov. 1954.

Port-Orford-cedar is shown to regenerate successfully after logging. Seedling establishment is closely related to number and distribution of seed trees.

Knauss, A. C. & Selbo, M. L. Research roots of the laminating industry. Forest Products Research Soc., Northeast Sect., Nov. 5-6, 1953, New Haven, Conn. Sec. 14. 6 pp.

Outlines certain historic facts about research done on glue laminating of wood that contributed materially to the development of the industry.

Knauss, A. C. (joint author with M. L. Selbo). Wood laminating comes of age. Jour. Forest Products Res. Soc. 4 (2): 69-76. April 1954.

Wood laminating has developed into an important wood industry in the past decade and a half. Present uses are described and history of research and actual experience are related. Laminating is expected to play an increasingly important part in wood utilization.

Knauss, A. C. (joint author with B. G. Anderson & Frashour, R. G.). Seasoning and machining degrade in young-growth Douglas-fir dimension lumber. Corvallis, Oreg., Forest Products Lab. Report No. D-1, 29 pp. 52 figures. May 1954. Processed.

Report of study to determine the extent and causes of degrade resulting from kiln drying young-growth Douglas-fir dimension lumber.

Matson, E. E. Forest utilization progresses. Western Conservation Jour. 11 (4): 22-24. July-Aug. 1954.

Summarizes improvements in forest utilization in the Pacific Northwest in the past 10-year period and outlines opportunities for further betterment in use of wood residue.

Morris, W. G. Rate of spread on a Washington fern fire. Fire Control Notes 15 (1): 32-34. Jan. 1954.

Lineal rates of spread for a short distance on various heads and flanks of an irregular fire on nearly level ground are given for an extremely dry and windy day and for a moderate day. Spread on the ground ranged from about 100 to 3,300 feet per hour, but spread by spotting reached 7,000 feet per hour.

Mowat, E. L. Effect of thinning and pruning on growth of young ponderosa pine. Northwest Science 28 (1): 18-25. Feb. 1954.

Removal of up to about one-third of the length of live crown has little effect upon growth, but more severe pruning may cause an undesirable reduction in both diameter and height growth. Some guidelines for thinning are given.

Shaw, E. W. Direct seeding in the Pacific Northwest. Jour. Forestry 52 (11): 827-828. Nov. 1954.

Reports on rodent problems, use of tetramine, and costs of seeding by helicopter.

Shaw, E. W. Review of "The Triumph of the Tree," by John Stewart Collis. Jour. Forestry 52 (6): 457. June 1954.

Staebler, G. R., Lauterbach, Paul, & Moore, A. W. Effect of animal damage on a young coniferous plantation of southwest Washington. Jour. Forestry 52 (10): 730-733. Oct. 1954.

Presents information on what happens to a plantation in the first four years of its life in an area of high animal populations.

Staebler, G. R. Management pays added profits in young Douglas fir. Timberman 55 (4): 74-76. Feb. 1954.

Records of permanent sample plots demonstrate the increasing values that accrue each year the harvest is delayed as timber approaches maturity.

Worthington, Norman. The loblolly pine of the South versus the Douglas fir of Pacific Northwest. Pulp & Paper 28 (10): 84-85, 87-88, 90. Sept. 1954.

Douglas-fir produces greater yield and increment than loblolly pine, but the pine produces earlier returns and more clear lumber.

Wright, Ernest (joint author with F. W. Deffenbacher). Refrigerated storage of conifer seedlings in the Pacific Northwest. Jour. Forestry 52 (12): 936-938. Dec. 1954.

Gives the results of tests of different methods of bundling seedlings and the combinations of humidity, temperature, and air circulation that permitted satisfactory storage up to six months and perhaps longer.

Wright, Ernest (joint author with R. M. Lindgren). Increased absorptiveness of molded Douglas-fir posts. Jour. Forest Products Res. Soc. 4 (4): 162-164. Aug. 1954.

Practical implications of the use of molds to increase penetration of sapwood of Douglas-fir are discussed, as well as tests undertaken to determine amount of increased penetration compared to mold-free control samples.

Multilithed Reports

Forest Survey Reports

113 Forest statistics for Clatsop County, Oregon, by F. L. Moravets. 24 pp. April 1954.

Results of Forest Survey reinventory of the forest resources of Clatsop County in 1952.

114 Forest statistics for Crook County, Oregon, by F. L. Moravets. 22 pp. May 1954.

Results of Forest Survey reinventory of the forest resources of Crook County in 1952.

115 Forest statistics for Jefferson Co., Oregon, by F. L. Moravets. 23 pp. June 1954.

Results of Forest Survey reinventory of the forest resources of Jefferson County in 1953.

116 Forest statistics for Deschutes Co., Oregon, by F. L. Moravets. 24 pp. July 1954.

Results of Forest Survey reinventory of the forest resources of Deschutes County in 1953.

117 Forest statistics for Kittitas County, Washington, by F. L. Moravets. 24 pp. Oct. 1954.

Results of Forest Survey reinventory of the forest resources of Kittitas County in 1953.

118 Forest statistics for Harney Co., Oregon, by F. L. Moravets. 23 pp. Nov. 1954.

Results of Forest Survey reinventory of the forest resources of Harney County in 1953.

Research Notes

95 Cold weather damages promising species in the Wind River Arboretum, by R. W. Steele. 7 pp. Jan. 1954.

Notes effects of severe winter of 1950 on exotic tree species of the arboretum. Introduced species may thrive for many years, but severe frost damage or complete loss is an ever-present peril.

96 1953 midsummer fuel moistures in Oregon and Washington national forests compared with other years, by O. P. Cramer. 3 pp. Jan. 1954.

Fuel moisture at 68 fire danger stations near the exterior boundaries of the national forests averaged slightly below the 1941-51 normal for the period July 16-August 31.

97 Two commercial thinnings in century-old Douglas-fir, by R. W. Steele. 5 pp. March 1954.

An illustration of two commercial thinnings that gave a profitable intermediate harvest, salvaged material that would have been lost through mortality, and improved the vigor of the stand.

98 Douglas-fir site as a basis for selecting Christmas tree lands, by E. W. Shaw. 2 pp. April 1954.

Shows how some stand characteristics, important for both Christmas trees and timber, vary by site class.

99 A preliminary study of the deterioration of alder and Douglas-fir chips in outdoor piles, by Ernest Wright. 5 pp. May 1954.

Indicates that mixing Douglas-fir chips with alder chips does not increase decay of the Douglas-fir. Instead, for this test at least, the presence of Douglas-fir chips retarded decay of the alder.

100 Natural reproduction of Shasta red fir from a single good cone crop, by W. I. Stein. 5 pp. July 1954.

A summary of results from a pioneering study to assess natural regeneration of Shasta red fir in southwestern Oregon.

101 Growth of pole-size ponderosa on cutover land in relation to selection of trees for pruning, by L. G. Gillmor and F. W. Jones. 2 pp. July 1954.

A study to provide a guide for selecting crop trees for pruning. Factors of dominance, stand density, site, and amount of release expected were shown to be important.

102 Effect of slash burning on soil pH, by R. F. Tarrant. 5 pp. July 1954.

Shows amount of rise in soil pH after various degrees of burning and the rate of return toward normal after weathering for a period of three years.

103 Estimating stand age for Douglas-fir, by F. A. Johnson. 2 pp. July 1954.

Presents a technique for adjusting estimates of stand age as obtained from dominant trees in Douglas-fir stands to stand age as defined by the Douglas-fir normal yield table.

104 Some results of chemical debarking on Sitka spruce, western hemlock, and red alder, by C. M. Berntsen. 7 pp. Sept. 1954.

Compares effect of various chemicals on loosening of bark. Sodium arsenite treatment was the most promising.

105 Soil reaction and germination of Douglas-fir seed, by R. F. Tarrant. 4 pp. Nov. 1954.

Germination rate of Douglas-fir seed is not impaired by high soil pH within limits found after slash burning.

106 1954 forest fire weather in western Oregon and Washington, by O. P. Cramer. 6 pp. Nov. 1954.

For the second successive year, severity of fire weather averaged far below normal during the April 1-October 31 fire season. Comparison is based on burning index and two rainfall occurrence indexes computed for key Weather Bureau stations.

107 Seed production on the Voight Creek Experimental Forest, 1950-1953, by E. W. Shaw. 4 pp. Dec. 1954.

Seed fall in heavy thinning was twice as great as average for entire area. Medium and light thinnings did not rate high in seed production. Where seed crop was light, viability decreased sharply.

Research Paper

10 Deterioration of beetle-killed Douglas-fir in Oregon and Washington, by Ernest Wright and K. H. Wright. 12 pp. June 1954.

A preliminary or progress report showing results of the study for the years 1952 and 1953. Rates of deterioration should be of value in planning salvage operations.

Miscellaneous Reports

Mowat, E. L. A guide to the Pringle Falls Experimental Forest, Lapine, Oregon. 24 pp. 1954.

Handbook for experimental forest visitors. Includes description of physical features of the area and details of research work accomplished or under way.

Ruth, R. H., comp. Cascade Head climatological data; 1936-1952. 29 pp. Jan. 1954.

Complete climatological data with foreword comments including observations on fog-drip contribution to total precipitation.

Staebler, G. R. Standard computations for permanent sample plots, as recommended by the Puget Sound Research Center Advisory Committee for use in western Washington. 15 pp. Dec. 1954.

Outlines standard methods of computations recommended for use in even-aged forest stands of western Washington. Purpose is to strengthen mensurational data through standardization and subsequent combination of data from all possible sources.

U. S. Forest Serv., Pacific Northwest Forest & Range Expt. Sta. Annual report - 1953. 68 pp. March 1954.

Detailed summary of accomplishments of the Station for the calendar year 1953 and statement of plans for 1954.

_____ A guide to the McCleary Experimental Forest, McCleary, Washington. 20 pp. 1954.

Handbook for experimental forest visitors. Includes description of physical features of the area and details of research under way.

_____ A program of tree-improvement research for the Pacific Northwest. 11 pp. Aug. 3, 1954.

States kinds of genetics research needed for Northwest forests, shows interrelation of the several phases of the program and indicates relative priority of the various tasks.

_____ (joint author with Oregon State Board of Forestry). Report of forest insect surveys in Oregon and Washington, season of 1954. 48 pp. Nov. 30, 1954.

An account of the principal forest insect outbreaks in Oregon and Washington in 1954.

U. S. Forest Serv., Pacific Northwest Forest & Range Expt. Sta. (in cooperation with Northwest Forest Pest Action Committee). Spruce budworm control plan for 1955 in Oregon and Washington. 15 pp. Nov. 1954.

Presents recommendations of committee for aerial spraying of 601,000 acres in the Blue Mountains Area of Oregon in 1955.